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Statistical Analysis of Ground Water Contamination at the Alert Apron and Northern Landfill Areas of Wurtsmith AFB, Michigan

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Final Report

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NOTICES

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Two plumes of contamination are analyzed to determine their extent, composition, and movement. The large number of ground water monitoring wells sampled over the past eight years at Wurtsmith AFB allow us to perform this analysis directly from empirical data, with minimal assumptions about solute transport mechanisms. Conclusions are drawn about the likely sources of contamination in the two plumes, the adequacy of the data for making risk assessments, and the likely consequences of alternative programs of remediation.

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EXECUTIVE SUMMARY

In 1979, the U. S. Geological Survey (USGS) identified three major plumes of contaminated ground water at Wurtsmith Air Force Base, Michigan. This report concerns two of these plumes, known as the Alert Apron and Northern Landfill plumes. The purpose of this current investigation is to report on the present status of the area affected by these plumes, identify any trends in the plumes since 1979, and comment on the accuracy of the U. S. Air Force's monitoring procedures. Tentative conclusions are drawn about the likely sources of contamination, the adequacy of the data for making risk assessments, and the likely consequences of implementing various remedial action alternatives.

Alert Apron Area

1. The principal contaminant in the Alert Apron area is 1,1,1- trichloroethylene (TCE), which is detected primarily in shallow wells that are screened at average depths of less than 30 feet.

2. A TCE plume delineated by the USGS in 1983, with probable source near the waste storage area west of the Alert Apron, has apparently been migrating off base in the direction of Van Etten Lake. Based on 1987 sampling results from the USGS, the highest levels of TCE in this plume are currently concentrated near the western shore of Van Etten Lake in the area of Pierce's well.

3. In 1980 the highest levels of TCE were found on base west of the Alert Apron, but these levels have decreased substantially, so that presently TCE occurs at concentrations below action levels in the area west of the apron. In addition, USAF data indicate a decreasing trend in TCE concentration for wells located centrally along the flow line of the plume.

4. Approximately 88 acres of the Alert Apron area, including the land between Wurtsmith AFB and Van Etten Lake, were above action levels (5 μg/L) of TCE in 1980, with a median concentration of 93 μg/L of TCE. In 1987, the affected area has diminished to 64 acres, with a corresponding drop in the median TCE levels to a concentration of 30 μg/L. Of the 64 affected acres, 54 acres are just within the eastern boundary of Wurtsmith AFB, while the remaining 10 acres are centered around well R29S, off base.

Northern Landfill Area

1. The prominent contaminants in the Northern Landfill area are benzene, TCE, 1,2-dichloroethylene (DCE), and vinyl chloride. These contaminants occur at highest concentrations in the shallow monitoring wells and to a lesser extent (i.e., lower concentrations and fewer wells) have also been detected in the deeper wells.

2. Vinyl chloride is the most extensively distributed contaminant of this group with a peak concentration of about 60 μg/L. Benzene is mainly restricted to the eastern edge of Wurtsmith AFB, and reportedly occurs at concentrations exceeding 2000 μg/L off base in the vicinity of Camp Nissokone. Peak DCE has decreased 90% from about 150 μg/L in 1980 and 1984 to about 15 μg/L in 1987. TCE has appeared above action levels at only three wells, and its peak levels have also decreased 90% from 130 μg/L in 1980 to about 13 μg/L in 1987.

3. In 1987 about 96 acres were above action level for vinyl chloride, 37 acres for benzene, 36 acres for TCE, and 21 acres for DCE. The areas with multiple contaminants were located in the central part of the plume.

U.S. Air Force Monitoring

1. Air Force water quality sampling results appear to be biased toward lower-than-actual readings. The major form of bias is a positive probability of nondetection when actual levels may be relatively high. For actual concentrations of 20 µg/L of TCE, the probability of nondetection is about 10%, decreasing to 1% as the levels of concentration increase to 45 µg/L or more.

2. Although sampling differences permit a direct comparison of only about 20% of the data collected by the Michigan Department of Natural Resources (MDNR) with USAF data, the measurements taken by these two agencies are fairly close for those wells monitored by both agencies during the same time period.

3. The monitoring strategy of the USAF was to sample extensively at just a few wells, whereas the other agencies sampled less frequently at a wider range of wells that were networked over a larger area.

Conclusions

1. The most likely source of contamination for the Alert Area plume is a single spill of less than 3-5 barrels of TCE near the waste storage area, sometime in the 1970s. There may also have been, or perhaps still exists, a second source of TCE in the vicinity of Pierce's well.

2. Details on the release mechanisms or the source at the Northern Landfill plume has not been evaluated; however, the anomalous levels of benzene detected off base indicate that a second source may occur locally on the Camp Nissokone property.

3. The maximum concentration of TCE measured by the USAF at any particular well is consistent with measurements made by the USGS and the MDNR at the same well during the same year. The widespread sampling represented in the combined data base of the three agencies provides a good basis for estimating exposure to contaminants other than TCE as well.

4. Without intervention, the Alert Apron plume could drop below action levels in less than 10 years. With a pump-and-treat program near Pierce's well, this time might be shortened by perhaps 2-4 years.

CONTENTS

ILLUSTRATIONS

Introduction

Problem

In 1977, 1,1,1-trichloroethylene (TCE) was detected in a water supply well on Wurtsmith Air Force Base, Michigan. At the request of the U. S. Air Force, the U. S. Geological Survey conducted a study that identified three major plumes of contamination. One of these, in the vicinity of Building 43, has undergone extensive purging. The other two, located in less critical areas, have been monitored since 1979. These two plumes, one in the Alert Apron area and the other in the Northern Landfill area, are the focus of this report.

The basic environmental issues at Wurtsmith AFB concern (1) the current status of these plumes--their location, extent, and composition, (2) identification of time-trends, and (3) the adequacy of the monitoring system. The technical analyses in this report address just these issues, but the report includes a discussion about risks imposed by the plumes and possible recourses for restoration of the area.

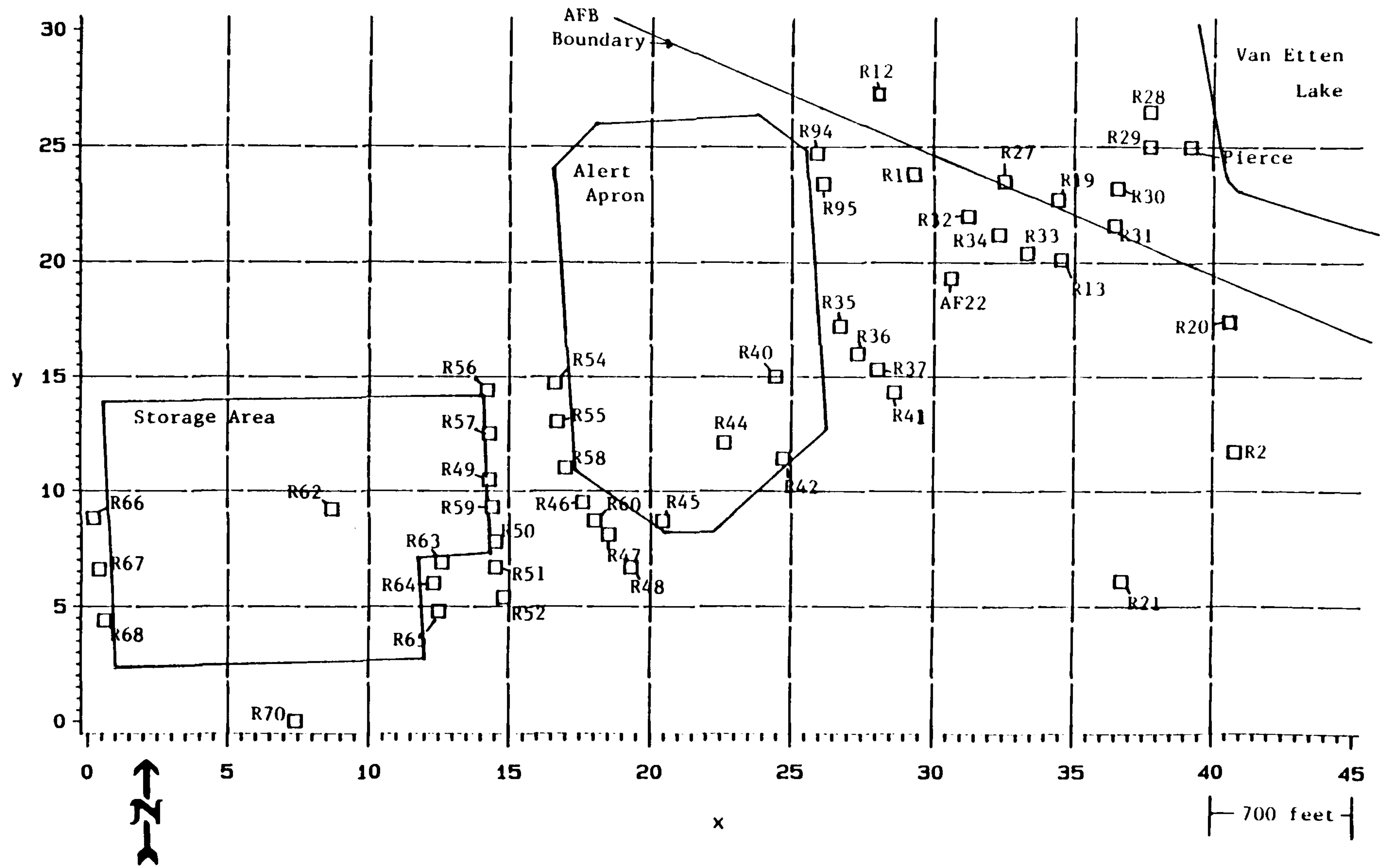
Setting

The Alert Apron area of Wurtsmith Air Force Base covers roughly the tract of land from southwest of the Alert Apron northeast to Van Etten Lake. The area has been affected by a ground water contamination plume beginning near the waste storage area on base and extending off base to Van Etten Lake. Figure 1a shows a plot of the monitoring wells located in the Alert Apron area. This plot has a superimposed grid showing the relative x,y coordinates. Also shown in Figure 1a are the locations of the Alert Apron, the storage area west of the Alert Apron, the base boundary, and Van Etten Lake. There were fifty-seven wells in the Alert Apron area at which ground water samples were taken. (Figure 1a shows fewer than fifty-seven locations because some deep and shallow wells were located at the same site.) Of these fifty-seven wells, forty-seven are shallow wells (average depth less than 30 feet), and the remaining ten are deep wells (average depth of 50 feet). Eight wells (including three deep ones) are located outside the boundaries of the base. Most of the monitoring wells in the Alert Apron area are located along a line from the storage area toward Van Etten Lake, which corresponds to the direction of the ground water flow in this area. This line also represents the center of the Alert Apron plume defined by the USGS [Stark, Cummings, and Twenter, 1983].

The Northern Landfill area extends north and east from the actual landfill to the YMCA camp and the shore of Van Etten Lake. The Northern Landfill plume begins at the landfill area and runs northeast toward Van Etten Lake, following the direction of ground water flow. Figure 1b is a grid (using the same coordinate system as that for the Alert Apron area) showing the location of the monitoring wells in the Northern Landfill area. This plot also shows the location of the landfill, the base boundary, the YMCA camp, and Van Etten Lake. There were 24 shallow and 10 deep wells monitored in the Northern Landfill area. Of these 34 wells, 12 are located on-base and the remaining 22 are located off-base. Most of these monitoring wells are drilled directly into the Northern Landfill plume defined by the USGS [Stark, Cummings, and Twenter, 1983]. Three wells north of the plume at the YMCA camp have also been monitored.

FIGURE 1a

Location of Wells
Alert Apron Area



x and y are relative longitude and latitude, respectively

Location of Wells
Northern Landfill Area

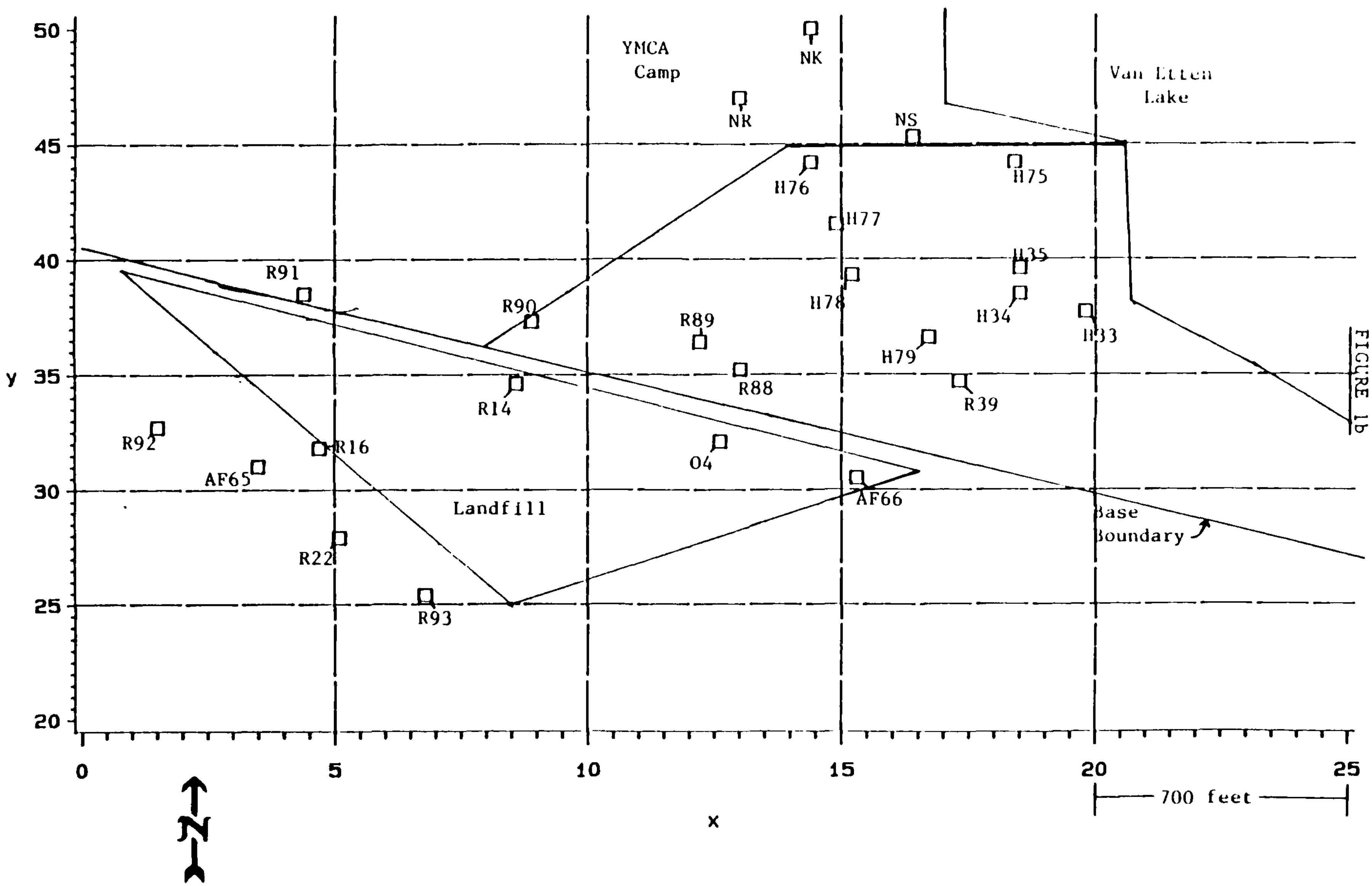


FIGURE 1b

x and y are relative longitude and latitude, respectively

The third area of interest is Van Etten Lake itself. The lake lies to the east of Wurtsmith AFB and is separated from the base by privately-owned land and the YMCA camp. The lake was infrequently sampled between 1981 and 1985 by the USAF and was sampled only once by the USGS in April 1984. Sampling took place at shallow and deep levels at various distances from shore near the Alert Apron plume. The USGS found contamination of TCE at levels acceptable for drinking water standards. The USAF found only TCE, and this only in the winter months when the lake was completely covered with ice. The lake showed no traces of contamination during the summer months when TCE might volatilize freely. Because the data are sparse, no further statistical analyses have been done for Van Etten Lake.

Approach

In the next section, we describe how the major contaminants were measured, as well as how each of the agencies involved conducted its sampling. Because of major differences in sampling strategies and the types of contamination, the Alert Apron and Northern Landfill areas are analyzed separately.

A global analysis of the Alert Apron area includes graphs illustrating the spatial migration, current spread, and depth of the TCE plume. More detailed analyses at individual wells are conducted to test for time-trends, measure seasonal variability, and estimate the reliability of U. S. Air Force measurements.

For the Northern Landfill area, the relative prevalence and spatial coincidence of four major contaminants are examined. Graphical methods are used to estimate the areal distribution and depth of each contaminant as well as its range of concentration levels.

DATA

The sections which follow discuss various aspects of the data used in this study. Topics discussed include the contaminants of interest, the sources of the data, and the sampling scheme. Appendix A contains a listing of the data from wells in the Alert Apron area, Appendix B contains data from Northern Landfill area wells for three of the contaminants of interest with vinyl chloride data contained in footnotes. Appendix C contains a listing of the data for the samples taken from Van Etten Lake.

Contaminants

The primary contaminants of interest in this study were 1,1,1-trichloroethylene (TCE), 1, 2-dichloroethylene (DCE), tetrachloroethylene (PCE), benzene (BEN), and vinyl chloride (VC). Vinyl chloride had not been specifically reported until 1987. The other chemical compounds were monitored throughout the entire study. It has been shown that PCE can be broken down into TCE, DCE, and vinyl chloride, consecutively, under anaerobic conditions [Vogel and McCarty, 1984]. Thus, these four compounds have a special relationship. Benzene has independent interest because very high levels of this contaminant were found in proximity to water supply wells located on the YMCA property.

Certain important values have been defined by the U. S. EPA for acceptable concentrations of contaminants in drinking water. One such value which will be used in our analyses is the action level, which defines the concentration at which action needs to be taken. The action levels for the contaminants in this study are as follows: TCE - 5 μg/L, DCE - 7 μg/L, PCE - 5 μg/L, benzene - 5 μg/L, and vinyl chloride - 2 μg/L. There are also values associated with the quantification methods used in measuring the concentrations of contaminants. The method detection limit is one such value which is of interest in our analyses. Approximate values for the method detection limits are as follows: TCE - 0.12 μg/L, DCE - 0.13 μg/L, PCE - 0.10 μg/L, benzene - 0.20 μg/L, and vinyl chloride - 0.10 μg/L.

The primary ground water contaminants monitored in the Alert Apron area were TCE, DCE, PCE, and benzene. A few other contaminants were detected at low levels at one or two Alert Apron area wells (see Appendix B), but they are not of interest in this study. Among all of these contaminants, the only one regularly observed at detectable levels at the Alert Apron area wells was TCE; hence, this is the only contaminant studied for this area.

The primary ground-water contaminants monitored at Northern Landfill area wells included TCE, DCE, benzene, and vinyl chloride. As mentioned above, vinyl chloride was first specifically reported in 1987, whereas the other contaminants were reported throughout the study. A number of secondary contaminants were detected at low levels at Northern Landfill area wells, but these are not of interest in this study (see Appendix C). All four of the primary contaminants were present, and all have been included in the analyses.

Sources and Sampling

There were three sources from which the data were drawn: the United States Geological Survey (USGS) [Stark, Cummings and Twenter, 1983; Cummings and Twenter, 1986; Cummings, 1987], the United States Air Force (USAF), and the Michigan Department of Natural Resources (MDNR) [Rodwan, 1987].

The sampling protocols for the Alert Apron area vary among these three agencies. In general, the strategy of the USGS was to monitor many wells, but only on an occasional basis. In contrast, the USAF monitored relatively few wells, but at much more frequent intervals. The MDNR has been involved in data collection since 1986; it has sampled less extensively, but more frequently than USGS. Table 1 shows the number of samples taken and the number of wells monitored by the various sources for various years.

The USGS monitored fifty-two wells (eight of them deep) in 1980 and early 1981, thirty-nine (six deep) in 1987, but seven (three deep) in 1984. Those that were omitted in 1987 were mainly wells to the west of the storage area where 1980 monitoring had found no contamination. The seven wells monitored in 1984 were all near the eastern boundary of Wurtsmith AFB, some on-base and others off-base.

The USAF monitored thirteen of the wells (three of them deep) in the Alert Apron area in the period from 1980 to 1987. Two wells were sampled about monthly from the spring of 1981 through the spring of 1987; four of the remaining nine wells were sampled between 15 and 25 times between 1980 and 1987; and the remaining wells were sampled less than five times each.

The MDNR collected samples on exactly four different occasions between November 1986 and June 1987. Most of the twenty-five wells monitored (of which five were deep) were sampled two or three times in that period, but there is no clear sampling pattern for the repeated measurements.

TABLE 1
Number of Wells and Observations Grouped by Years and Sources

	Alert Apron Area					
	USGS		USAF		MDNR	
	Wells	Obs	Wells	Obs	Wells	Obs
1979-1980	50	79	1	2	0	0
1981-1982	2	2	6	72	0	0
1983-1984	8	8	7	103	0	0
1985-1986	0	0	11	98	14	14
1987	30	30	9	20	22	27

	Northern Landfill Area					
	USGS		USAF		MDNR	
	Wells	Obs	Wells	Obs	Wells	Obs
1979-1980	10	21	2	2	0	0
1981-1982	20	21	4	37	0	0
1983-1984	20	25	4	53	0	0
1985-1986	0	0	5	47	0	0
1987	23	23	5	8	2	4

In the Northern Landfill area, the same degree of variation occurred in the sampling schemes. The USGS monitored nineteen (five deep), twenty (six deep), and twenty-three (eight deep wells in 1980, 1984, and 1987, respectively. For each year, between one and three

samples were collected at each monitored well. The wells monitored in 1987 included many of the same wells that had been monitored in 1980, but the wells monitored in 1984 were chosen to be closer to Van Etten Lake, to the north and east of the wells sampled in 1980 and 1987. This lack of regularity in sampling limits the types of comparisons that may be made from one time period to another.

The USAF monitored only five wells (one deep) in the Northern Landfill area between 1980 and 1987. One of these was monitored monthly and the other four were sampled between eight and twenty-two times each over the same period. The MDNR collected only four samples, two each from wells H78S and H78D, all taken on 3 June 1987.

There are two important types of errors in the data that can be estimated if laboratory and sampling replicates are included. The first type of error is measurement error, which represents the error in the quantification of the contaminants due to the particular methods and standards being used. This type of error can be estimated if a sample is split and the subsamples are analyzed separately. The second type of error is the sampling error and represents the error that occurs due to the method for selecting a particular sample. If multiple samples are taken at the same time and analyzed separately, the sampling error can be estimated. In all of the samples taken, there were never any replicate chemical analyses performed on a sample, nor were there any cases when more than one sample was taken at a given well on the same day (except for the MDNR samples of wells H78S and H78D). Thus, the measurement error and sampling error cannot be estimated in this study.

Analysis for Alert Apron Area

The analyses that follow are divided into three parts. The first is a group of analyses based on all of the USGS data from wells in the Alert Apron area. Results are presented concerning the spatial distribution of the TCE plume, how TCE levels in the plume have changed from 1980 to 1987, the depth of TCE contamination, and the estimated acreage at various levels of contamination in the future. We emphasize that all of the results presented in this part are based on only the USGS data. The second part is based on USAF data gathered for two wells which were monitored monthly for a period of six years. These analyses are concerned with the trends over time at a single location. The third part is a study of possible bias in the USAF data.

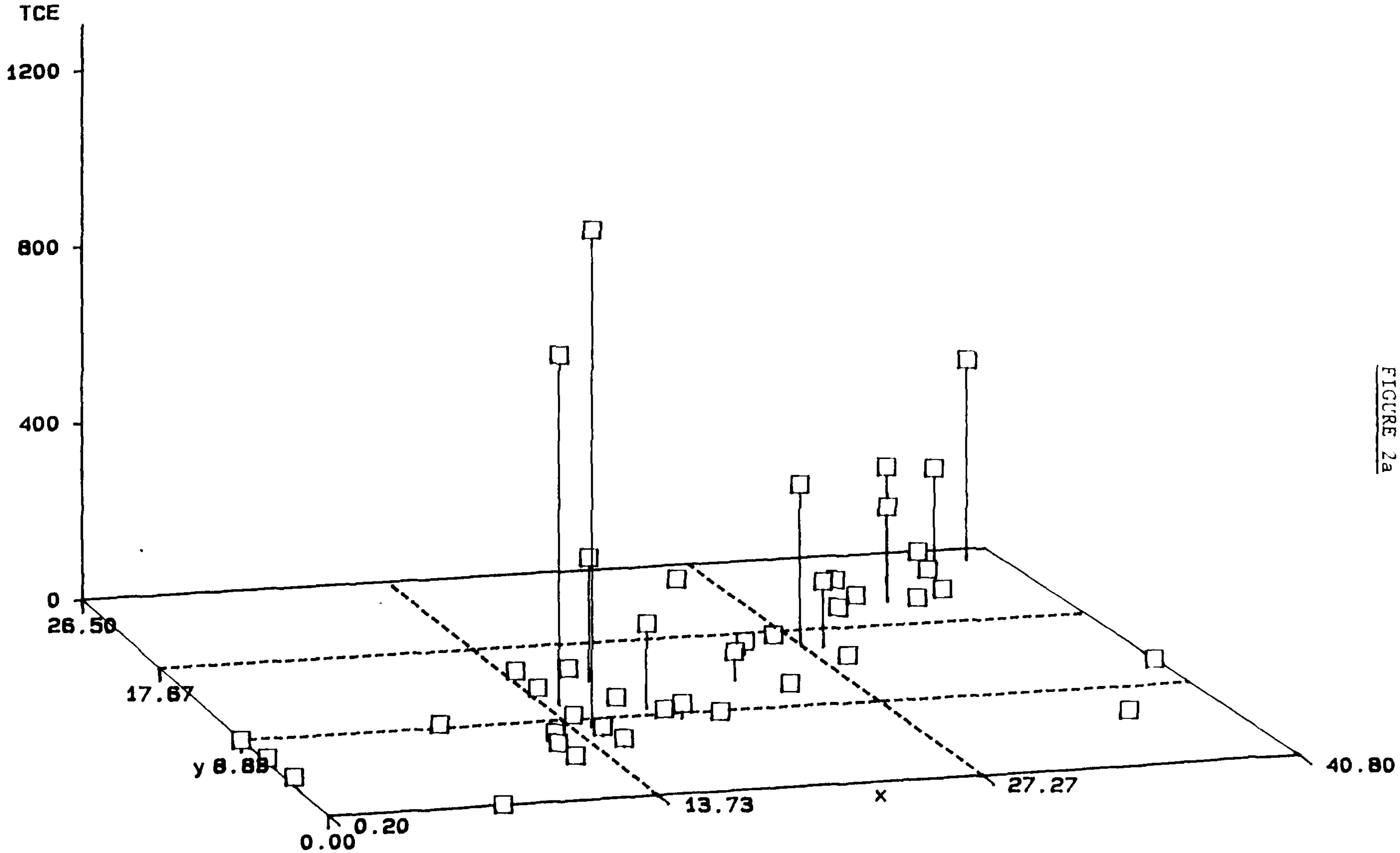
Part I – Analyses Based on USGS Data

Spatial Migration of TCE

Figures 2a and 2b illustrate the concentration of TCE at individual shallow wells in 1980 and 1987, respectively. These observations were smoothed over the entire Alert Apron area using spline techniques [SAS/GRAPH, 1985, pp. 413-424; Meinguet, 1979], resulting in the three-dimensional representations of TCE concentration over the Alert Apron area as shown in Figures 3a and 3b. Figure 3a indicates a continuous plume along the major flow line of ground water. This plume contains two areas of intense concentration that appear as peaks in the Figure. The most prominent peak, centered at coordinates (14,10) just east of the storage area, has concentrations as high as 600 μg/L (although well R50S in this area had a median TCE concentration of 1074 μg/L). A second peak, centered at coordinates (40,25) at the Pierce well, has concentrations nearly as high. For 1987, Figure 3b covers the part of the Alert Apron

FIGURE 2a

TCE at Individual Wells
Alert Apron Area - 1980



TCE concentration measured in ug/l
x and y are relative longitude and latitude, respectively

Source: USGS Water Resource Investigations Report 83-4002

FIGURE 2b

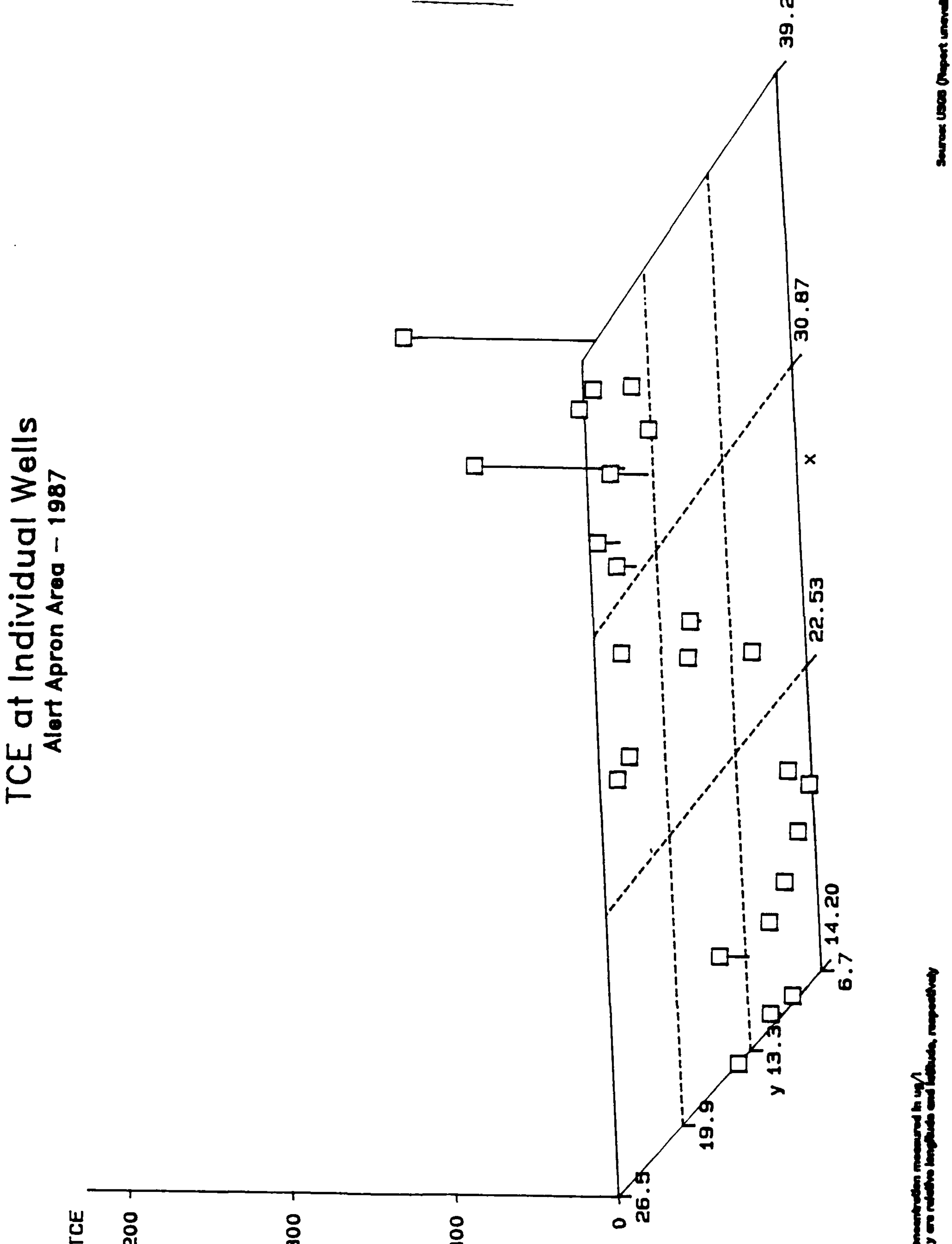
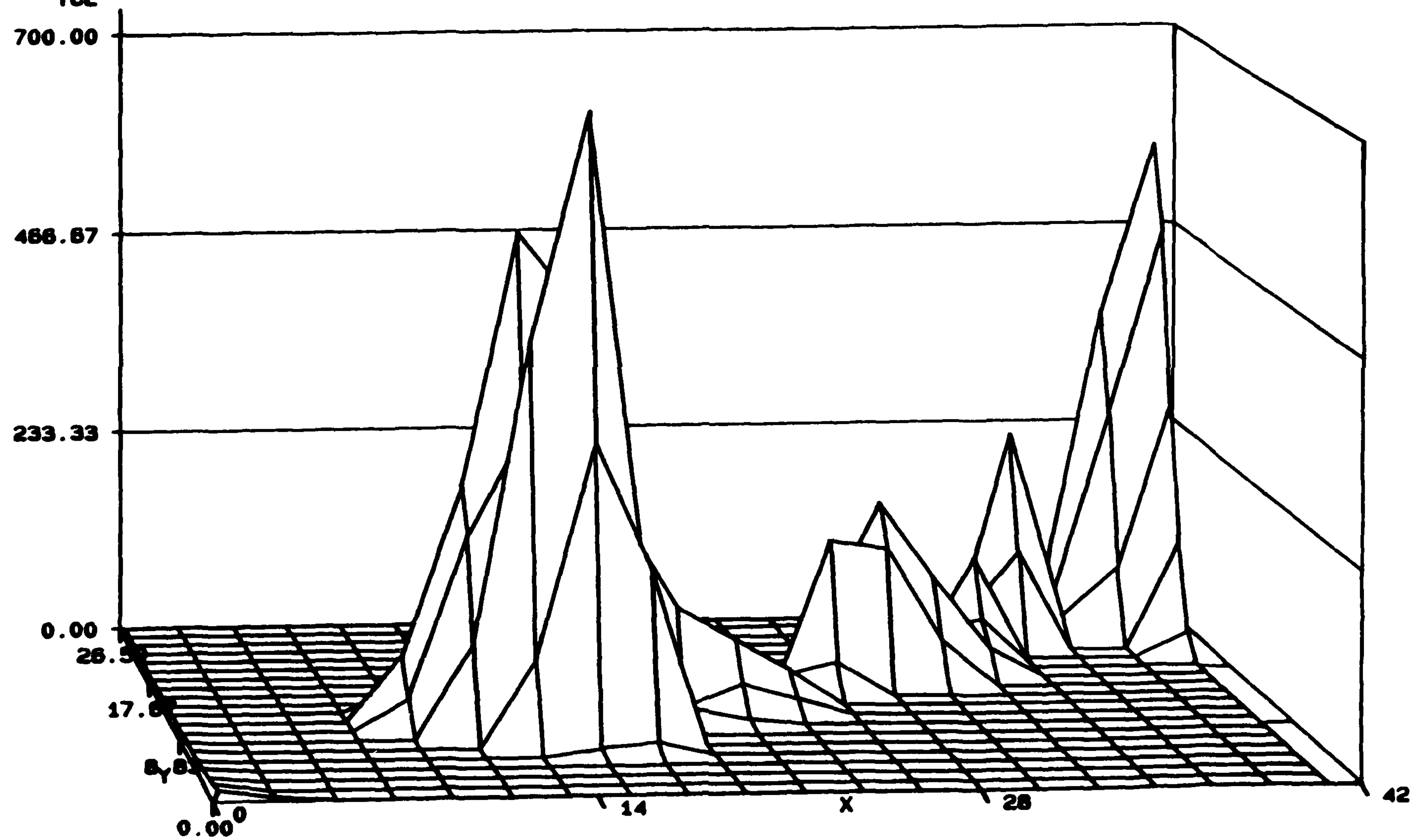

TCE at Individual Wells
Alert Apron Area – 1987
TCE
1200
800
400
0
26.5
19.9
y 13.3
6.7
14.20
22.53
x
30.87
39.20
TCE concentration measured in ug/l
x and y are relative longitude and latitude, respectively
Source: USGS (Report unavailable)

Figure 3a

Spatial Distribution of TCE

Alert Apron Area – 1980



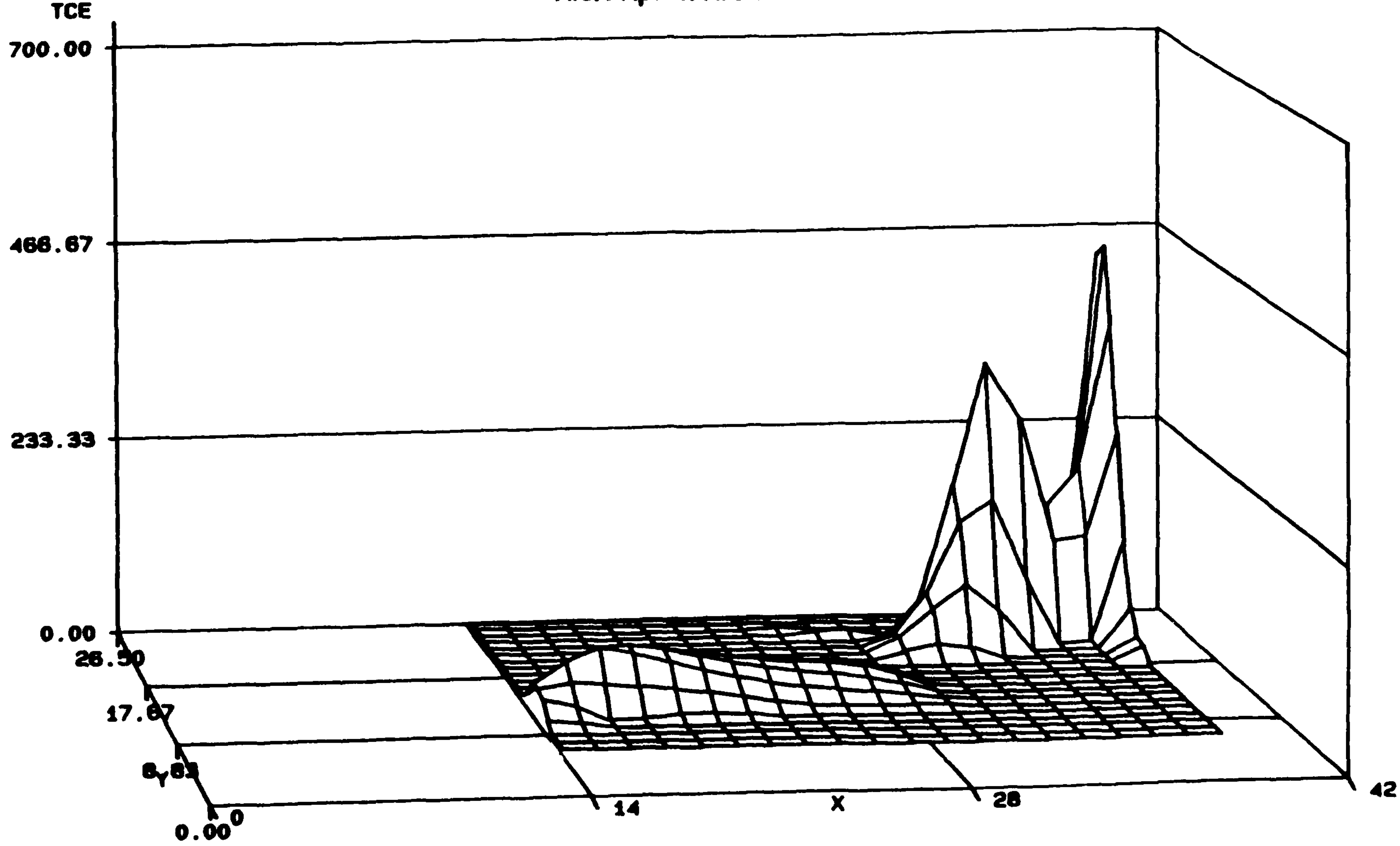
TCE concentration measured in ug/l
x and y are relative longitude and latitude, respectively

Source: USGS Water Resource Investigations Report 83–4002

Figure 3b

Spatial Distribution of TCE

Alert Apron Area – 1987



TCE concentration measured in ug/l
x and y are relative longitude and latitude, respectively

Source: USGS (Preliminary Data)

from the original peak just east of the storage area to the edge of Van Etten Lake. It shows that concentrations in the area of the original peak have greatly diminished but that concentrations near the lake (specifically Pierce's well) have remained at levels of almost 450 µg/L. Figure 4a compares the 1987 versus 1980 TCE readings at those shallow wells monitored during both years. The 1987 readings are represented by triangles and the 1980 readings by squares. The x-coordinates were obtained by projecting each well in a perpendicular direction onto the major flow line, so that the wells to the left are upgradient and the wells to the right are downgradient relative to the direction of groundwater flow. Of the 20 wells shown, only four had higher values of TCE in 1987 than in 1980, and in only one of these was the difference greater than 50 µg/L. Notably, all four of these wells were downgradient, toward Van Etten Lake. Figure 4b is similar to 4a, except that wells with observations during only one of the two periods are also included.

The simplest interpretation of these graphs is that a slug of contamination near the storage area in the 1970s has moved along the flow line to the area just west of Van Etten Lake. Some of the TCE near the shore in 1980 has probably diffused into the lake. This interpretation is consistent with a transport rate of about 0.5 feet/day of ground water along the major flow line, which is within the range mentioned in Stark, et. al. (1983).

General levels of TCE and its impact

Figure 5 charts the approximate acreage at various levels of TCE concentration for the years 1980 and 1987. About 88 acres of the Alert Apron area (including some of the land between Wurtsmith AFB and Van Etten Lake) were estimated to be above action levels of TCE in 1980. In 1987, the estimated affected area has shrunk to 64 acres. Of these 64 affected acres, 54 are within but near the eastern boundary of Wurtsmith AFB, and the remaining 10 acres are off-base, centered around well R29S.

Figure 5 also demonstrates that the distribution of TCE concentrations has shifted substantially from 1980 to 1987. In areas that were above the action limit of 5 µg/L, the median concentration of TCE was 93 µg/L in 1980, whereas the median concentration is 30 µg/L in 1987.

Assuming a TCE solute transport rate of .25 feet/day, which corresponds to a ground water flow rate of .5 feet/day, a simple analytical dispersion model predicts about a 10 year period for TCE to drop below its action level across the entire Alert Apron area. Unfortunately, dispersion here is not simple nor uniform, and the empirical change in concentration levels of the plume indicated in Figure 5 suggests a somewhat longer period, perhaps as much as 20 years.

Depth of Contamination

The issue of the depth of the transport of TCE is addressed in Figures 6a and 6b. Figure 6a depicts 8 wells where the USGS drew samples at both deep (approximately 50 feet) and shallow (less than 30 feet) levels in 1980. With the notable exception of well R36D, where 372 µg/L of TCE was measured, none of the deep wells reported levels of TCE above the action level. In 1987 (Figure 6b), the TCE concentration at the deep well R36D has diminished to 20 µg/L, but at the same time, one other deep well (R27D) on the eastern border of Wurtsmith base shows a concentration (12 µg/L) above action level.

FIGURE 4a

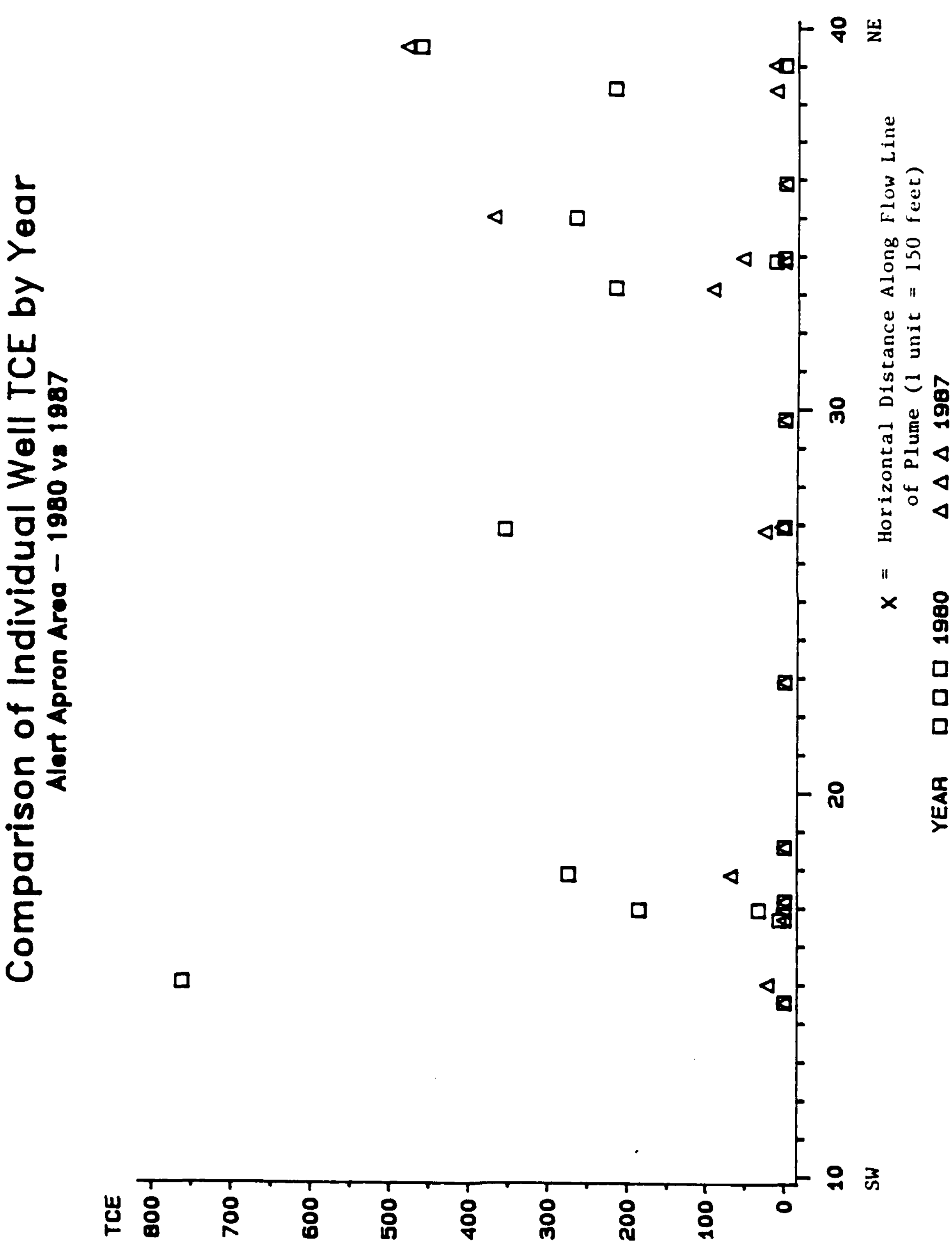

Comparison of Individual Well TCE by Year
Alert Apron Area -- 1980 vs 1987
TCE
800
700
600
500
400
300
200
100
0
10
20
30
40
SW
NE
X = Horizontal Distance Along Flow Line of Plume (1 unit = 150 feet)
YEAR □ □ □ 1980 Δ Δ Δ 1987

FIGURE 4b

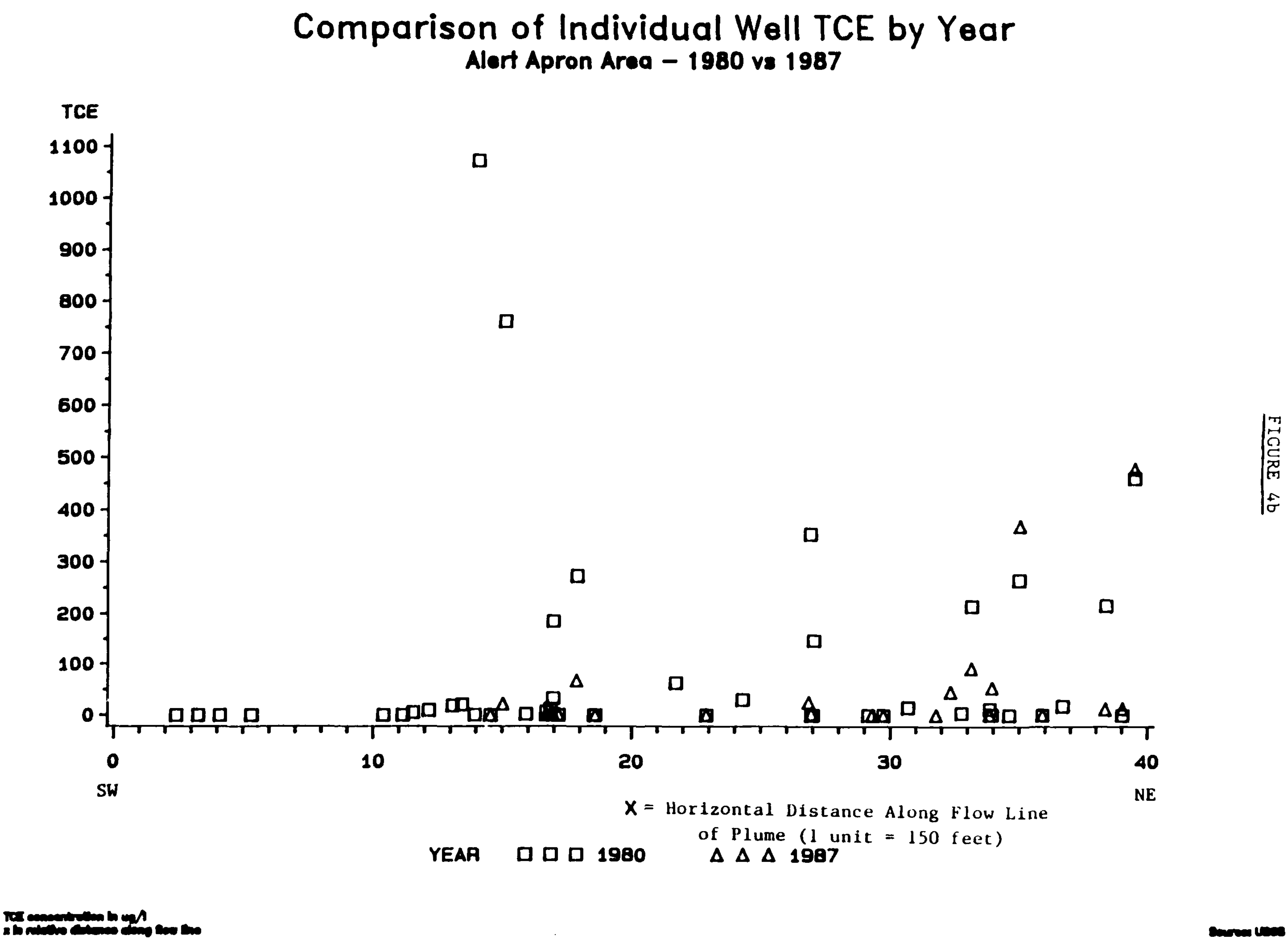

Comparison of Individual Well TCE by Year
Alert Apron Area – 1980 vs 1987
TCE
1100
1000
900
800
700
600
500
400
300
200
100
0
0
10
20
30
40
SW
NE
X = Horizontal Distance Along Flow Line of Plume (1 unit = 150 feet)
YEAR □ □ □ 1980 △ △ △ 1987
TCE concentration in ug/l
x is relative distance along flow line
Source: USGS

FIGURE 5

Estimated Total Area Containing Various TCE Levels

Alert Apron Area — 1980 and 1987

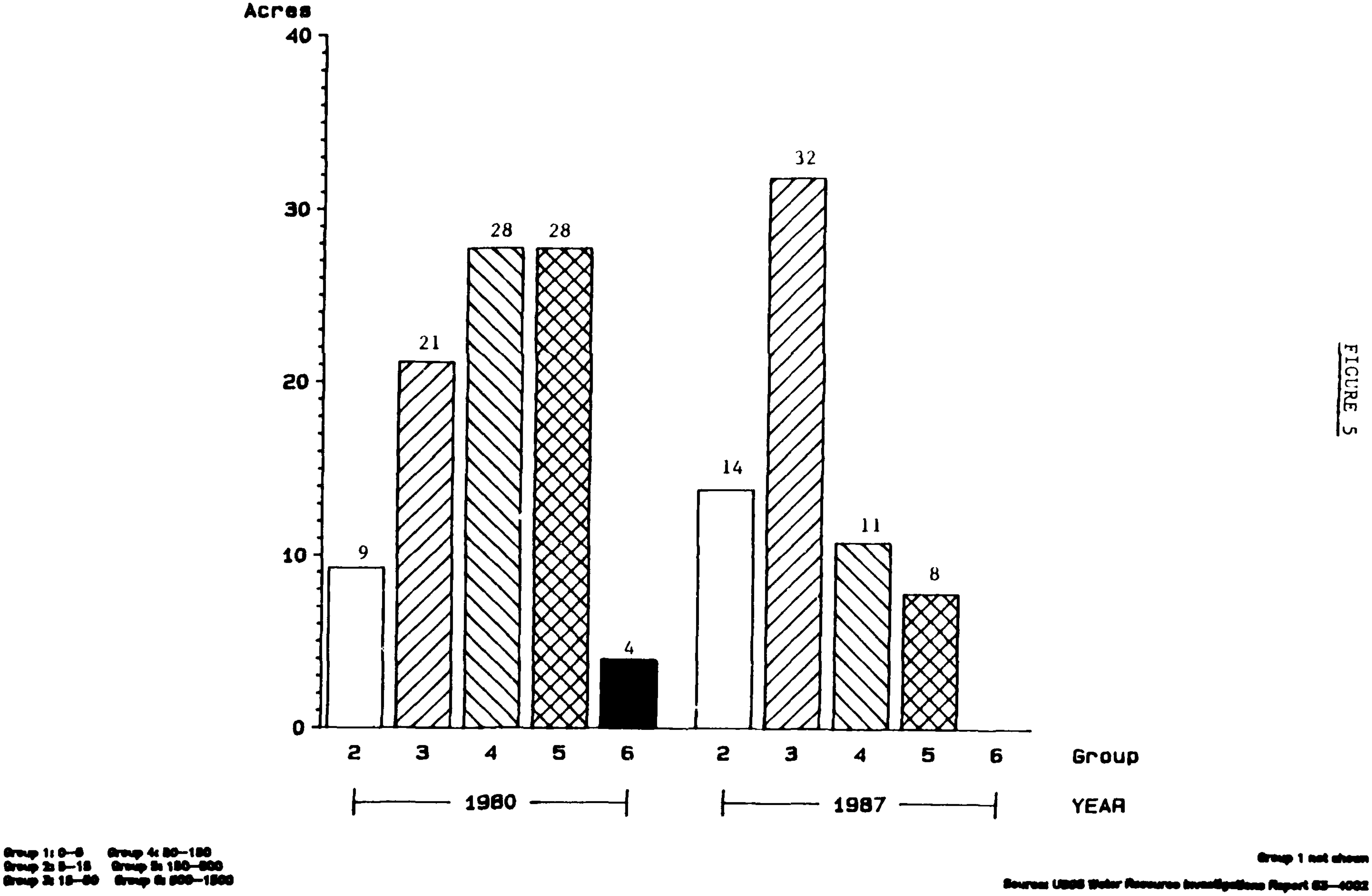
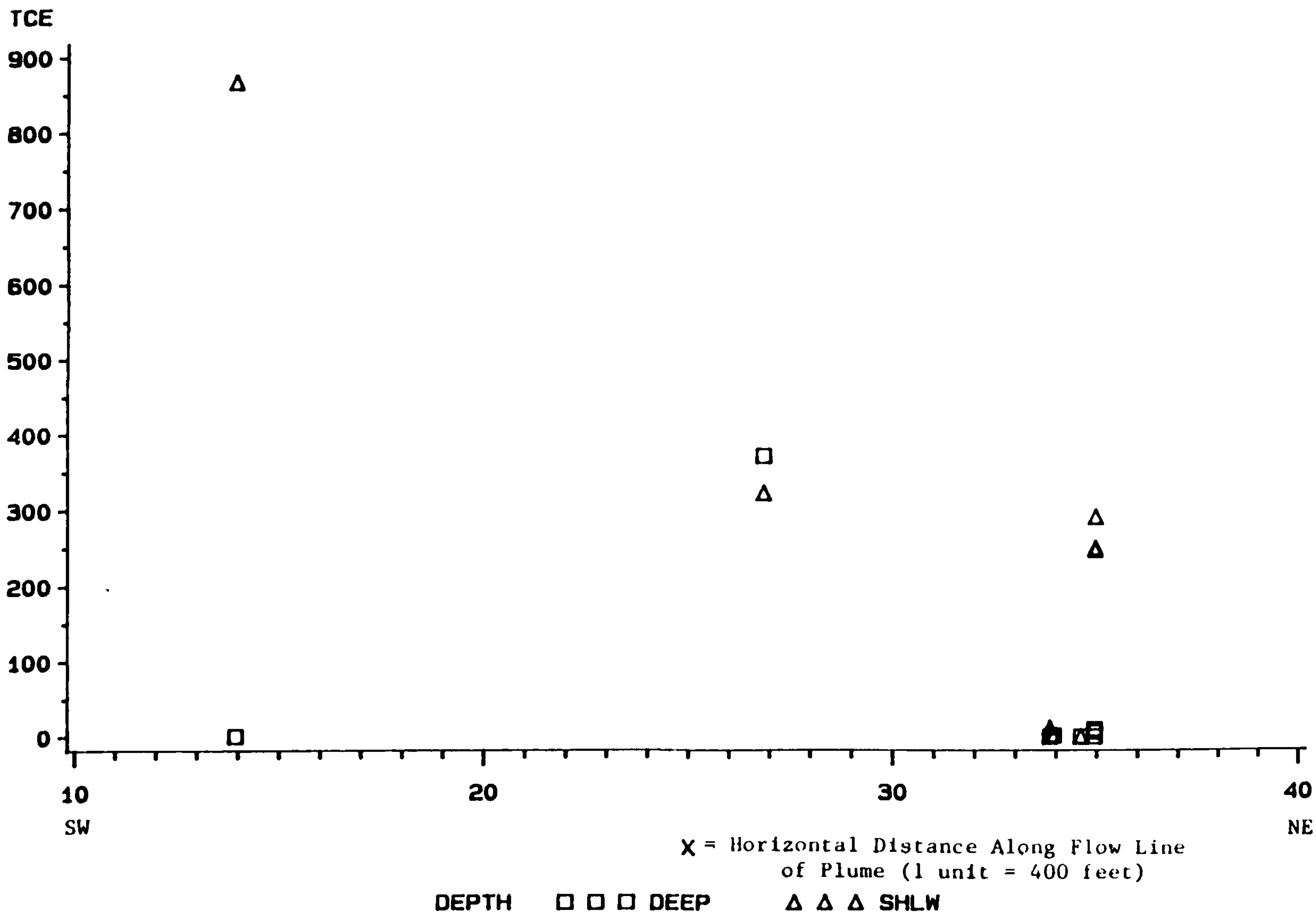


FIGURE 6a

Comparison of Deep and Shallow Wells

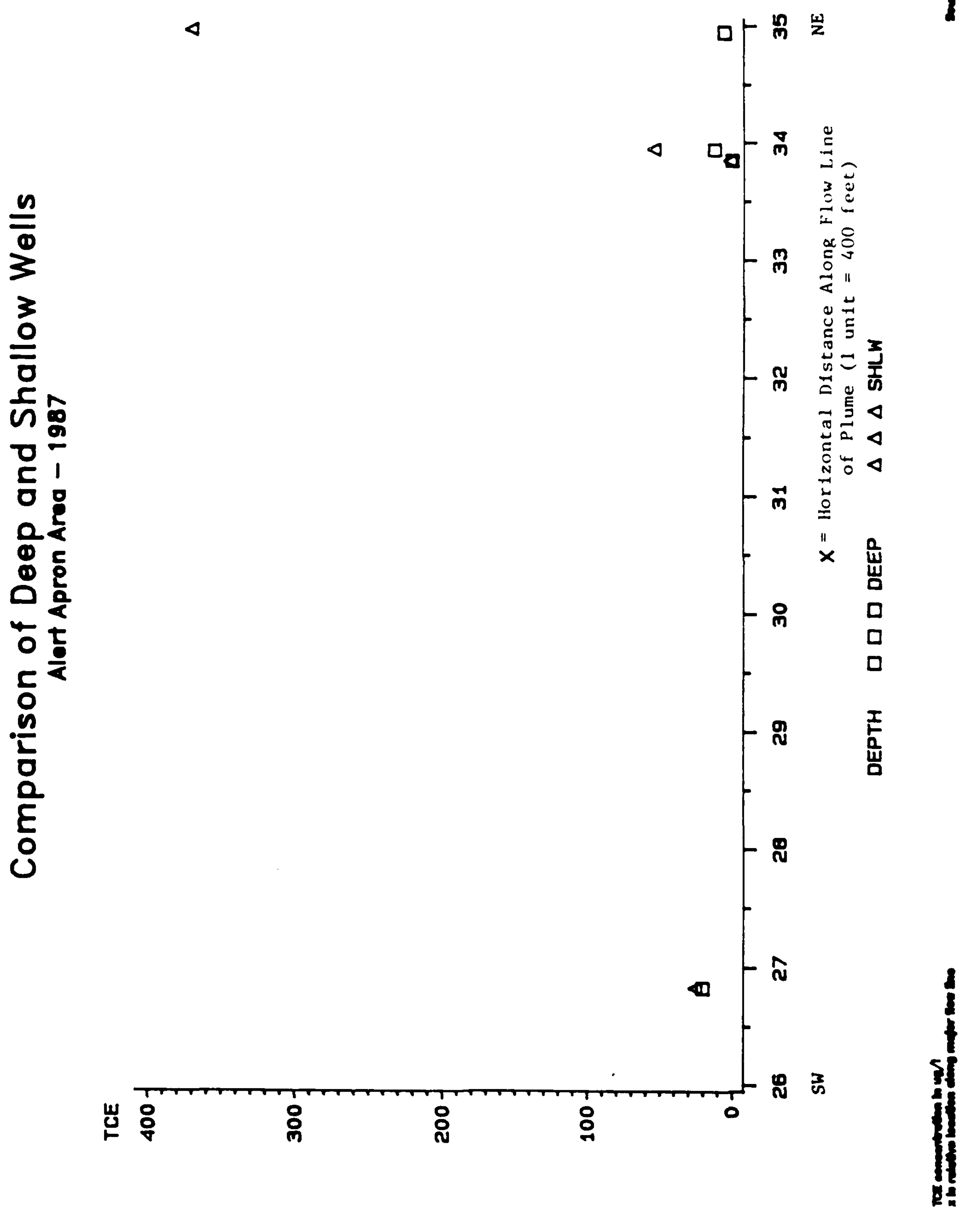
Alert Apron Area – 1980



TCE concentration in ug/l
x is relative location along major flow line

Source: USGS and USAF

FIGURE 6b


Comparison of Deep and Shallow Wells
Alert Apron Area – 1987
TCE
400
300
200
100
0
26
27
28
29
30
31
32
33
34
35
SW
NE
X = Horizontal Distance Along Flow Line of Plume (1 unit = 400 feet)
DEPTH □ □ □ DEEP Δ Δ Δ SHLW

A comparison of TCE concentrations at shallow and deep levels suggests that the major system of transport of TCE is through the shallow flow regime of the aquifer. A deep transport system is implausible because the USGS piezometer data [Cummings and Twenter, 1986] indicate that ground water flow turns upward near Van Etten Lake. This type of flow means that TCE would have to appear in the deep wells west of the lake if it were travelling through a deep flow system. The absence of TCE in the deep wells west of Van Etten Lake corroborates the theory that TCE flow is mainly through the shallow levels of the aquifer.

Part II – Analyses Based on USAF data

Analyses at individual wells

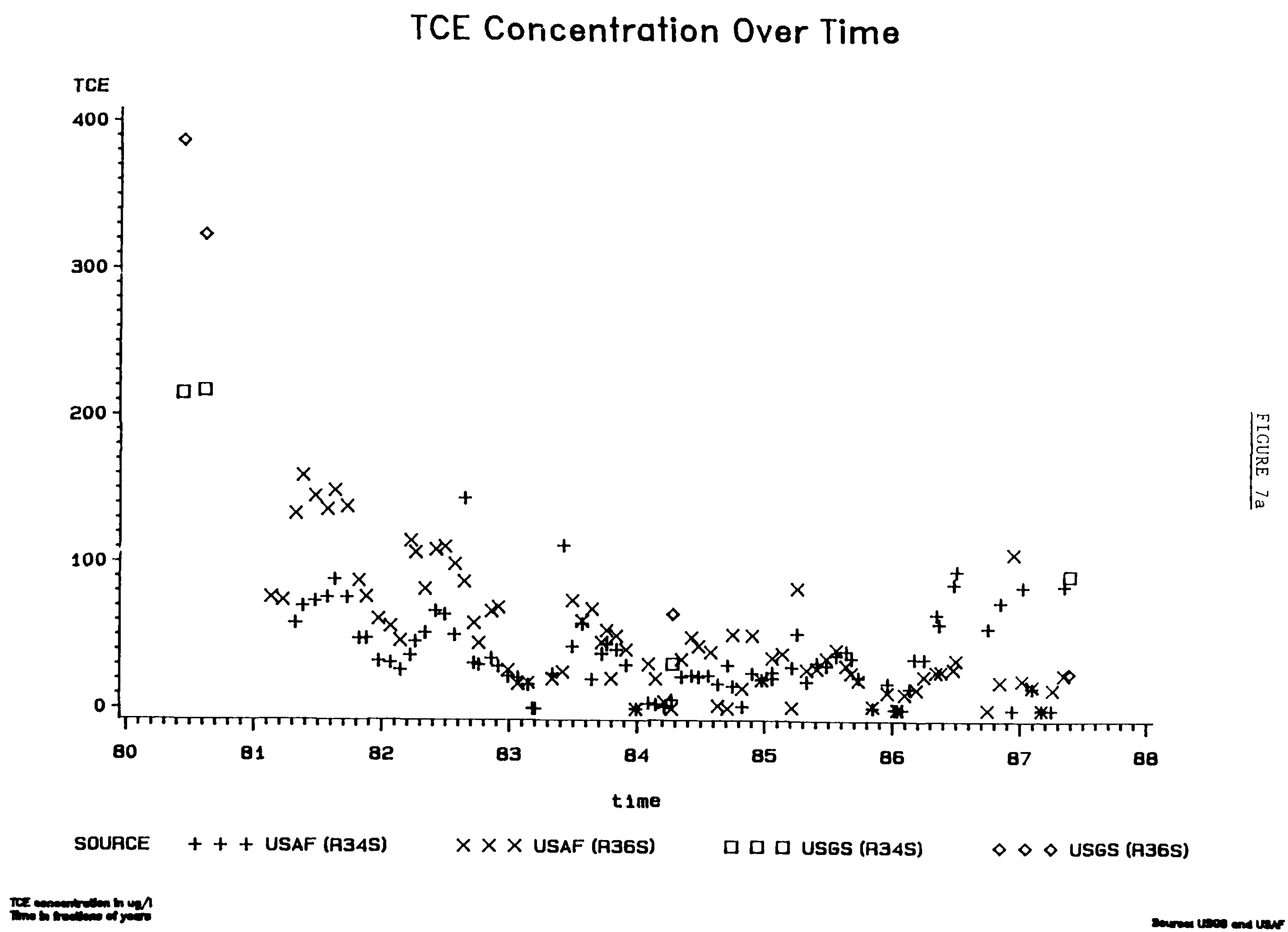
The USAF monitored two wells, R34S and R36S, east of the Alert Apron at approximately monthly intervals from April 1981 to June 1987. These were the only two wells in the Alert Apron area selected for such extensive monitoring, and, thus, they afford the opportunity for a more detailed analysis. The USGS also sampled at these wells in 1980, 1984, and 1987; the MDNR sampled at these wells in 1987.

Figure 7a, which includes the data from the USAF and the USGS, shows the plot of TCE versus time for wells R34S and R36S. The 1980 USGS readings of TCE at each of the wells are much higher than all later readings. In 1984 the USGS readings decreased sharply but were about 50 μg/L larger than those of the USAF. In 1987 the values from the USGS and USAF were in close agreement. The readings taken by the MDNR in 1987 were also close to those of the other two sources.

Figure 7b plots the logarithm of TCE concentration [log(TCE+1)] versus time. This relationship should be approximately linear (with TCE decreasing over time) if the main factor governing the long-range trend of TCE is a function of an exhausted or significantly curtailed contaminant release. It is believed that the waning levels of TCE reflect a finite quantity of contamination being effectively flushed through the relatively rapid hydrologic flow system. Additionally, it is considered likely that the mechanism controlling the dropping levels of TCE are related to aquifer recharge and concomitant dilution, and perhaps biological degradation. In support of this scenario and based on adjustments made for seasonality, a small but statistically significant linear trend was found. This was determined based on the exception of 11 values that were apparently too low. The systematic feature of the outliers suggests a possible bias in the USAF measurements. We have already noticed the tendency for the USAF measurements to be lower than those of the USGS, and we shall investigate this possible bias in more detail later.

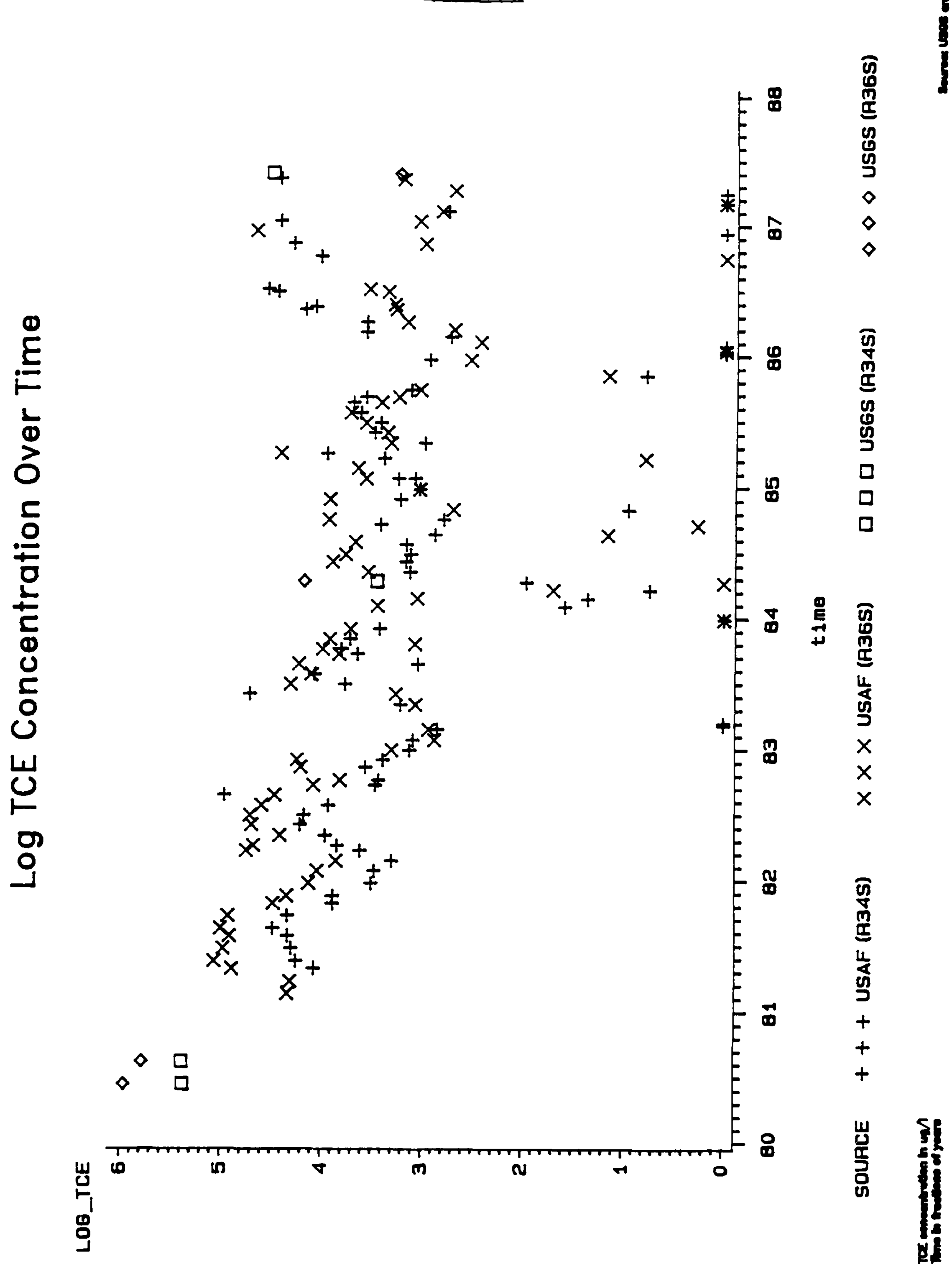
To highlight the seasonality of the data, the data were smoothed by repeatedly replacing each observation with the median of the three nearest observations in time. The smoothed curves appear in Figures 8a (estimated TCE versus time) and 8b [estimated log(TCE+1) versus time]. The curves show approximately year-long cycles of varying amplitudes and shapes that are remarkably similar for the two wells. The sample correlation between simultaneous observations at the two wells is 0.78 which reflects the fact that the two wells are affected by the same seasonal influences. In addition to seasonal effects, the data also display serial dependence. Autocorrelations were obtained after subtracting an estimated linear trend value from each observation. First and second order auto-correlations were 0.40 and 0.32, respectively, for well R34S and 0.55 and 0.37, respectively, for well R36S, all of which were statistically significant.

FIGURE 7a



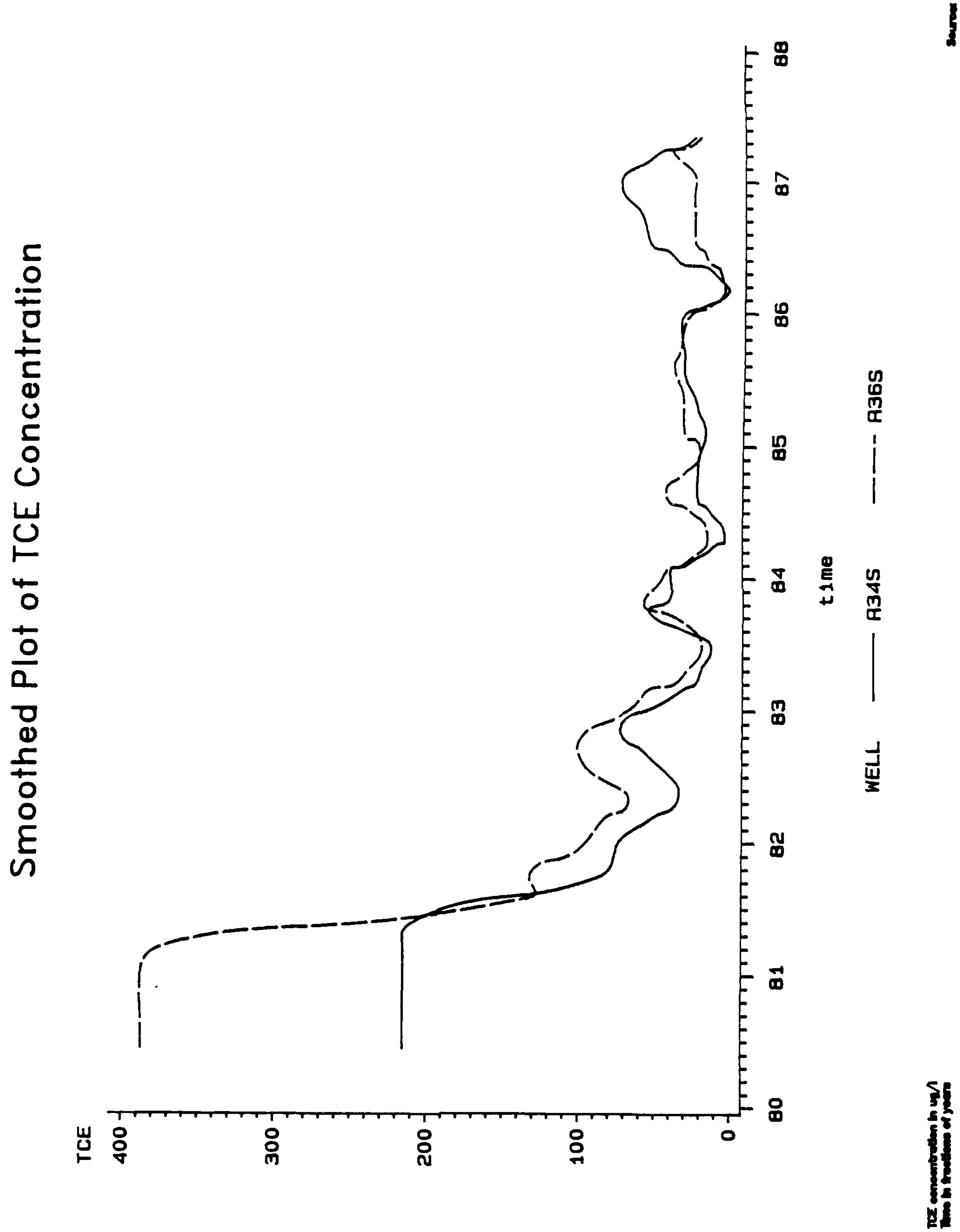
TCE Concentration Over Time
TCE
400
300
200
100
0
80
81
82
83
84
85
86
87
88
time
SOURCE
+ + + USAF (R34S)
X X X USAF (R36S)
□ □ □ USGS (R34S)
◇ ◇ ◇ USGS (R36S)
TCE concentration in ug/l
Time in fractions of years
Source: USGS and USAF

FIGURE 7b



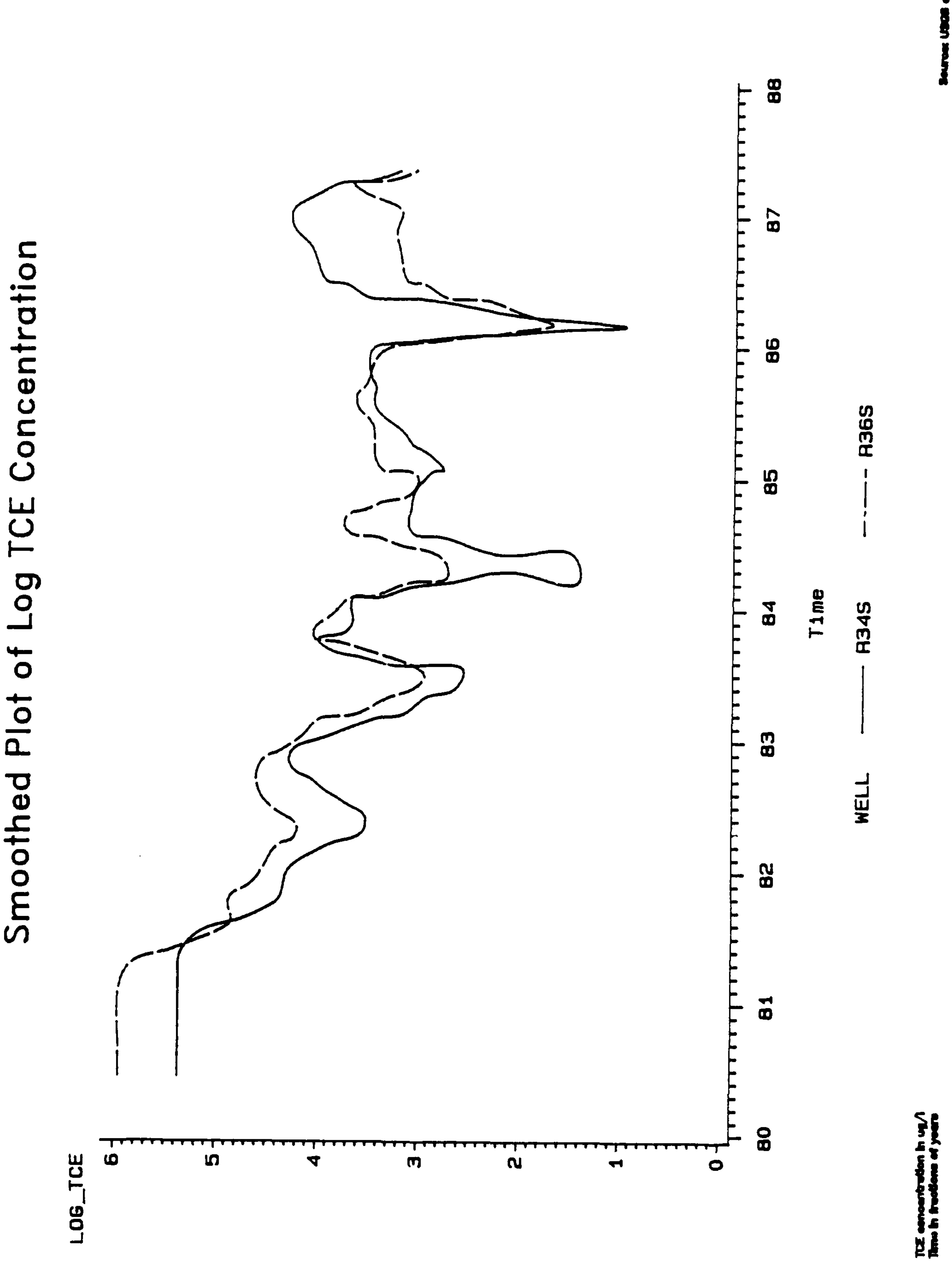
Log TCE Concentration Over Time
LOG_TCE
0
1
2
3
4
5
6
80
81
82
83
84
85
86
87
88
time
SOURCE + + + USAF (R34S) X X X USAF (R36S) □ □ □ USGS (R34S) ◇ ◇ ◇ USGS (R36S)
TCE concentration in ug/l
Time in fractions of years
Source: USGS and USAF

FIGURE 8a



Smoothed Plot of TCE Concentration
TCE
400
300
200
100
0
80
81
82
83
84
85
86
87
88
time
WELL —— A34S - - - A36S
TCE concentration in ug/l
Time in fractions of years
Source: USGS and USAF

FIGURE 8b


Smoothed Plot of Log TCE Concentration
LOG_TCE
6
5
4
3
2
1
0
80
81
82
83
84
85
86
87
88
Time
WELL —— R34S --- R36S
TCE concentration in ug/l
Time in fractions of years
Source: USGS and USAF

A formal nonparametric trend test for seasonal data with serial dependence was conducted according to the protocol of Hirsch and Slack (1984). For well R34S, the test statistic $z = -1.4$ (which has an asymptotic normal distribution) was inconclusive, whereas for well R36S, the test statistic $z = -2.3$ was significant at the 0.01 level. The discrepancy of these results is due to an apparent upturn in the values at well R34S for late 1986 and early 1987.

Part III -- Analyses Comparing Data Sources

Source Bias

The three data sources, USGS, USAF, and MDNR, were compared to see if they agreed about the locations and levels of contaminants found in the aquifer. At each well, observations from one source were matched with the temporally-nearest observation from the other sources, as long as the observations were within one year of each other.

This type of pairing led to relatively few matches between the USGS and the USAF (twelve), most of which were for wells R34S and R36S. The resulting USGS-USAF pairs were comparable except in four cases. In two of these cases, the time lag was one year, which could possibly account for the USAF reporting lower values; in the other two cases, the USAF failed to detect TCE when the USGS reported levels of 10 and 20 μg/L. The results suggest that the USAF and the USGS are in generally close agreement, but when there is a discrepancy, the USAF measurements are lower.

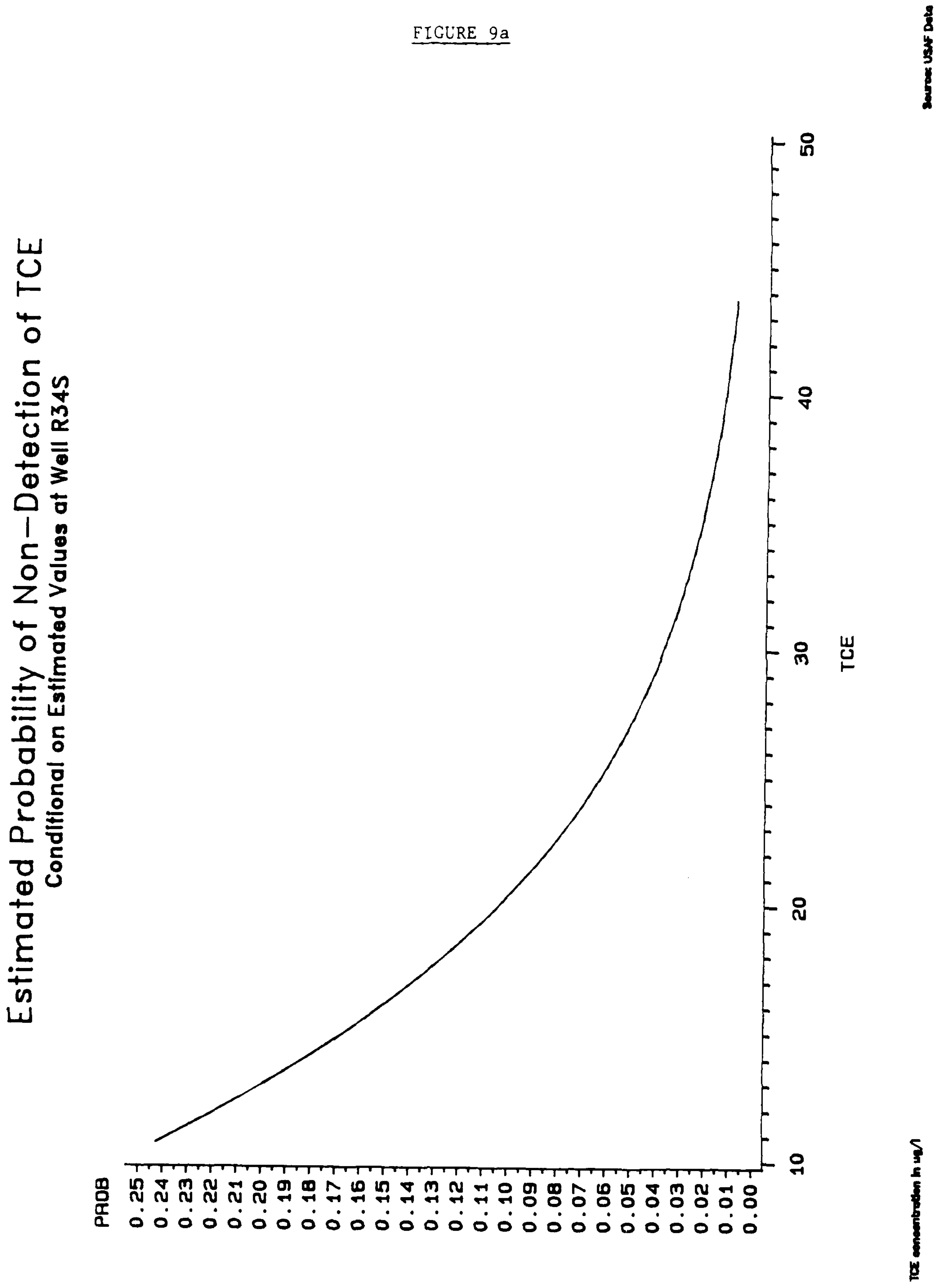
Pairing of USGS and MDNR data produced 20 matches. In only three of these was there a discrepancy, and the MDNR measurements were lower in each case. Of the 10 matches between the USAF and the MDNR, there were two discrepancies, one with the USAF values slightly lower, and one with the USAF about three times higher. A second method was used to validate the USAF data based on information from wells R34S and R36S. Because there is so much data from these two wells, smoothed curves for TCE versus time can be used to provide good estimates of the actual TCE levels at each time point. As is apparent from Figure 7b, the outliers tend to be nondetects or lower-than-expected measurements, indicating a bias in USAF data toward underestimating TCE.

In order to quantify the USAF bias, we concentrated on estimating the probability that the USAF would not detect a value, which, by all indications of the other data, was above action levels. For each well separately, we first fit a curve to estimate TCE at any point in time and then performed a logistic regression of the event of nondetection versus the estimated value of TCE. This regression provides an estimate of the probability of nondetection as a function of the estimated TCE concentration. The results are displayed in Figures 9a and 9b. For TCE levels of about 20 μg/L there is a 10% chance of nondetection, but this chance reduces to 1% for TCE levels above 45 μg/L.

Analyses for Northern Landfill Area

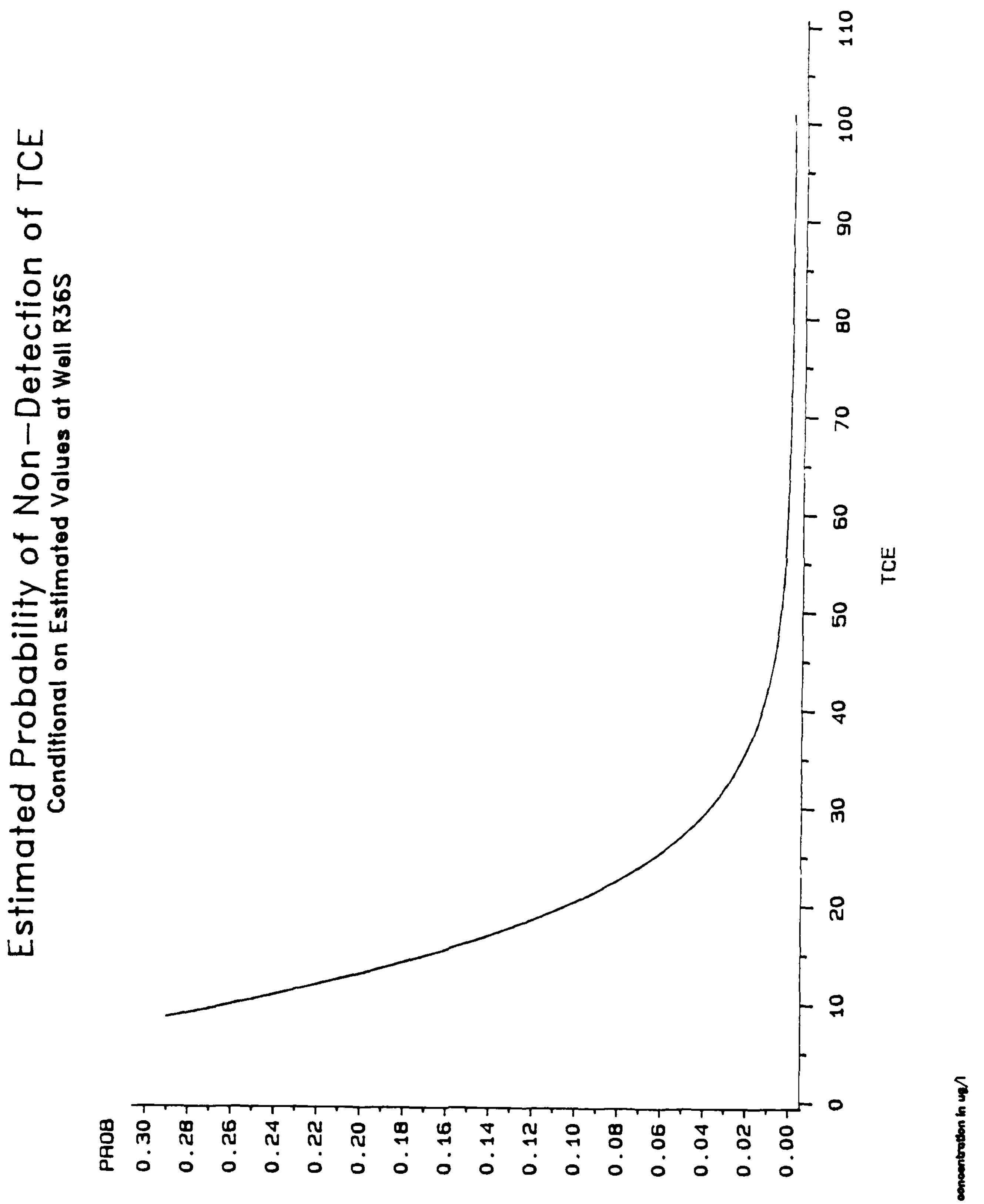
The sparseness of data for the Northern Landfill area limits the types of analyses that may be undertaken for this area. Here we simply compare the prevalence of the contaminants of interest, estimate the spatial distribution of individual contaminants, and evaluate the depth of the contamination.

FIGURE 9a



Estimated Probability of Non-Detection of TCE
Conditional on Estimated Values at Well R34S
PROB
0.25
0.24
0.23
0.22
0.21
0.20
0.19
0.18
0.17
0.16
0.15
0.14
0.13
0.12
0.11
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
10
20
30
40
50
TCE
TCE concentration in ug/l
Source: USAF Data

FIGURE 9b


Estimated Probability of Non-Detection of TCE
Conditional on Estimated Values at Well R36S
PROB
0.30
0.28
0.26
0.24
0.22
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
0
10
20
30
40
50
60
70
80
90
100
110
TCE
TCE concentration in ug/l
Source: USAF Data

Comparison of contaminant prevalence

Acreage above action level was estimated by spline fitting the spatial distributions of the contaminants (see Figures 12-15). These estimates appear in Table 2, together with median and maximum concentrations measured in the plume.

TABLE 2
Spline Smoothing Estimates of the Area Above Action Levels in the Northern Landfill Plume in 1987

contaminant	est. extent (acres)	concentration (µg/L) median	maximum
TCE	36*	26	68
DCE	21	9	16
VC	96	11	61
BEN	37*	39	2065

*Because of steep peaks, a logarithmic transform was first applied.

Figure 10 shows the number of wells reporting actionable, below-actionable, and nondetected levels of each of the four primary contaminants in 1987. Clearly, vinyl chloride is the most prevalent contaminant, detected in two-thirds of the wells and measured above action levels in half of them. At the other extreme, TCE appears in only three of the wells, two at concentrations above the action level.

Because TCE, DCE, and VC are closely linked, they are displayed in Figure 11 by a combined contour plot of the areas where each exceeded the action limits. From this Figure, we see that there is no strong association between the locations of the three contaminants.

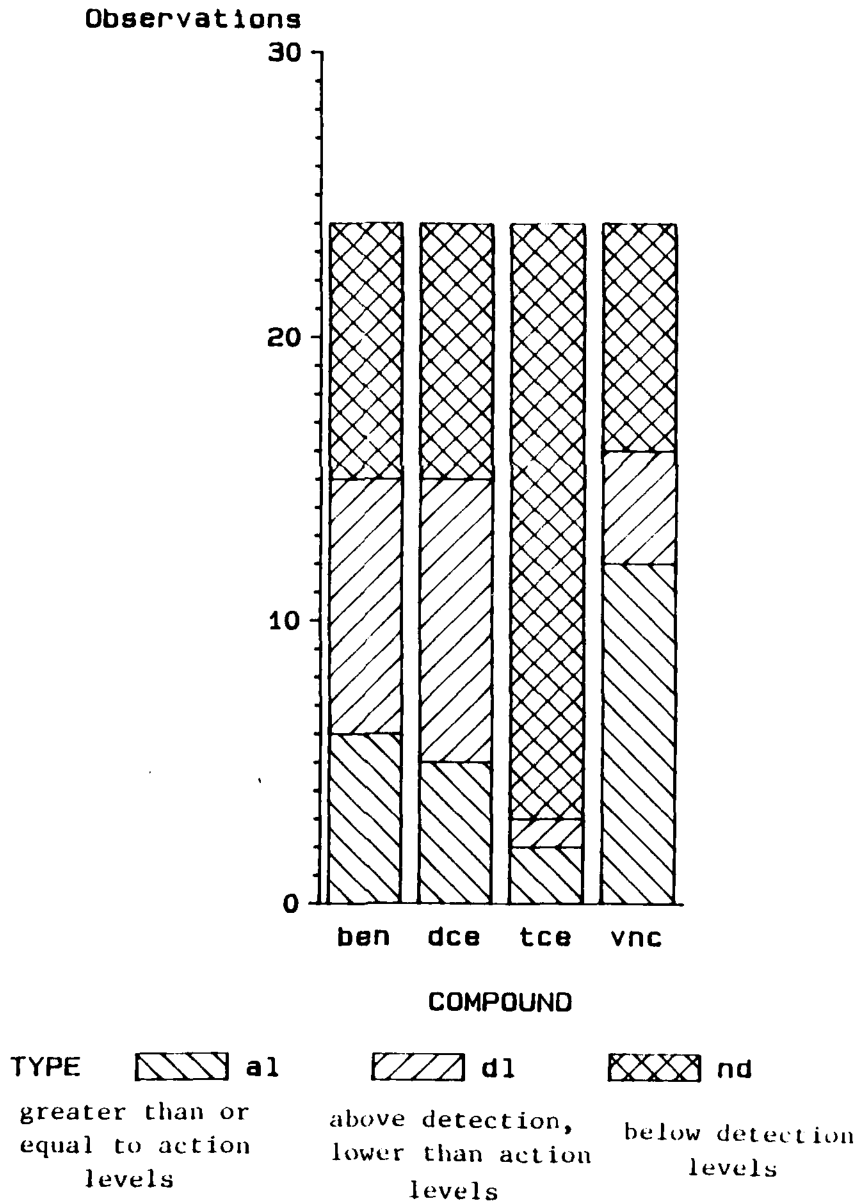
Area containing specific contaminants

In 1980, benzene levels were fairly low throughout the northern landfill area. The peak concentration of 10 µg/L was reported at well R14S with a secondary peak of 8 µg/L near well AF65. Figure 12a displays the estimated spatial distribution of benzene throughout the shallow levels of the aquifer in 1980. The levels of benzene reported in 1984 and 1987 were comparable to those found in 1980 with the exception of well H78S. In 1984 the measured concentration had risen to 200 µg/L (see Figure 12b) and in 1987 to 2100 µg/L (see Figure 12c). Data from the MDNR confirms this last exteme value, with measured benzene concentrations of 3000 µg/L and 2900 µg/L in two separate samples on June 3 1987.

FIGURE 10

Comparison of Observed Levels of Four Compounds

Northern Landfill Area – 1987



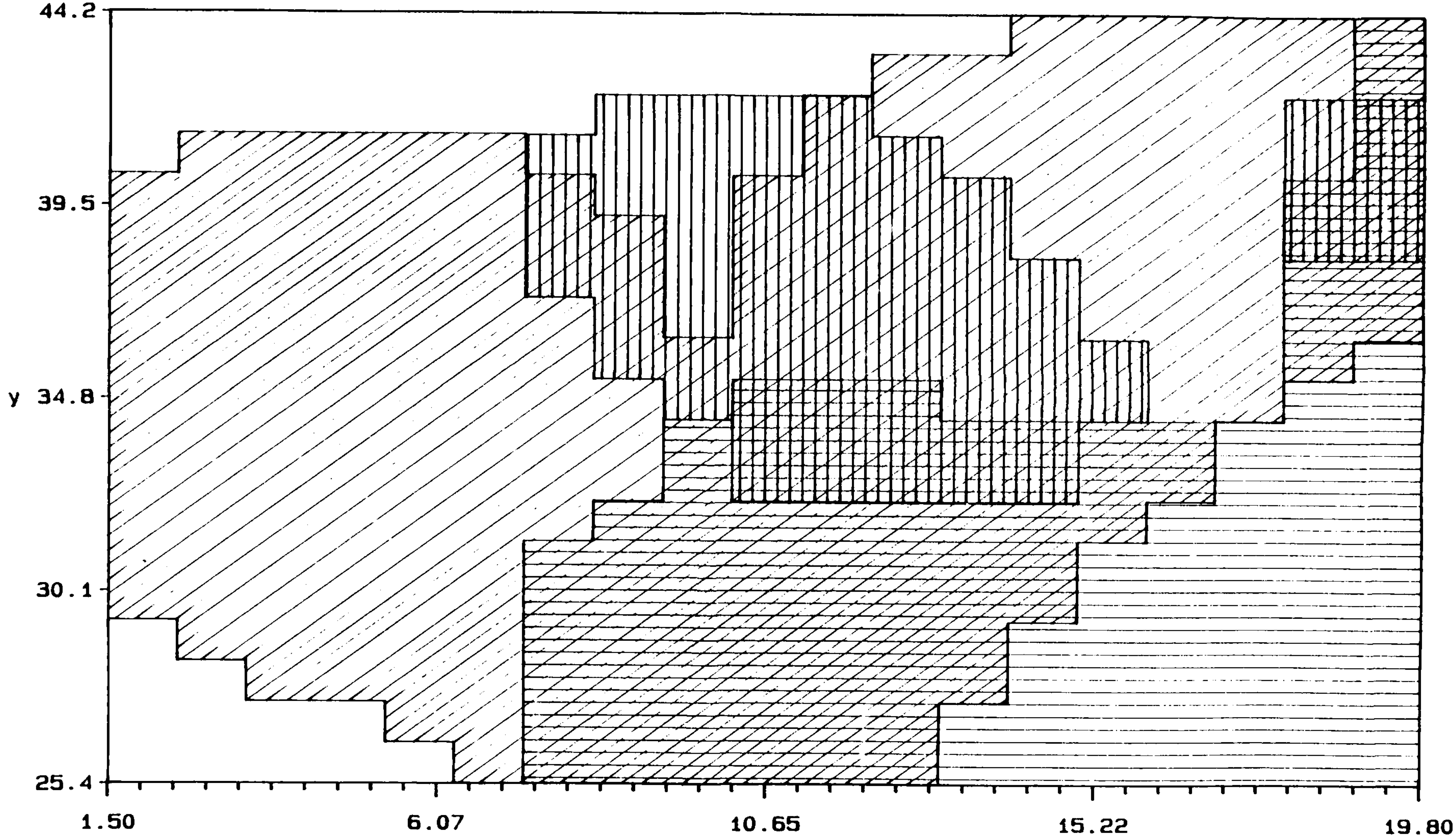
nd – not detected
dl – detected but not action level
al – above action level

Source: USGS and USAF

FIGURE 11

Areas Containing Action Levels of Three Compounds

Northern Landfill Area – 1987



Horizontal – TCE
Vertical – DCE
Diagonal – Vinyl Chloride

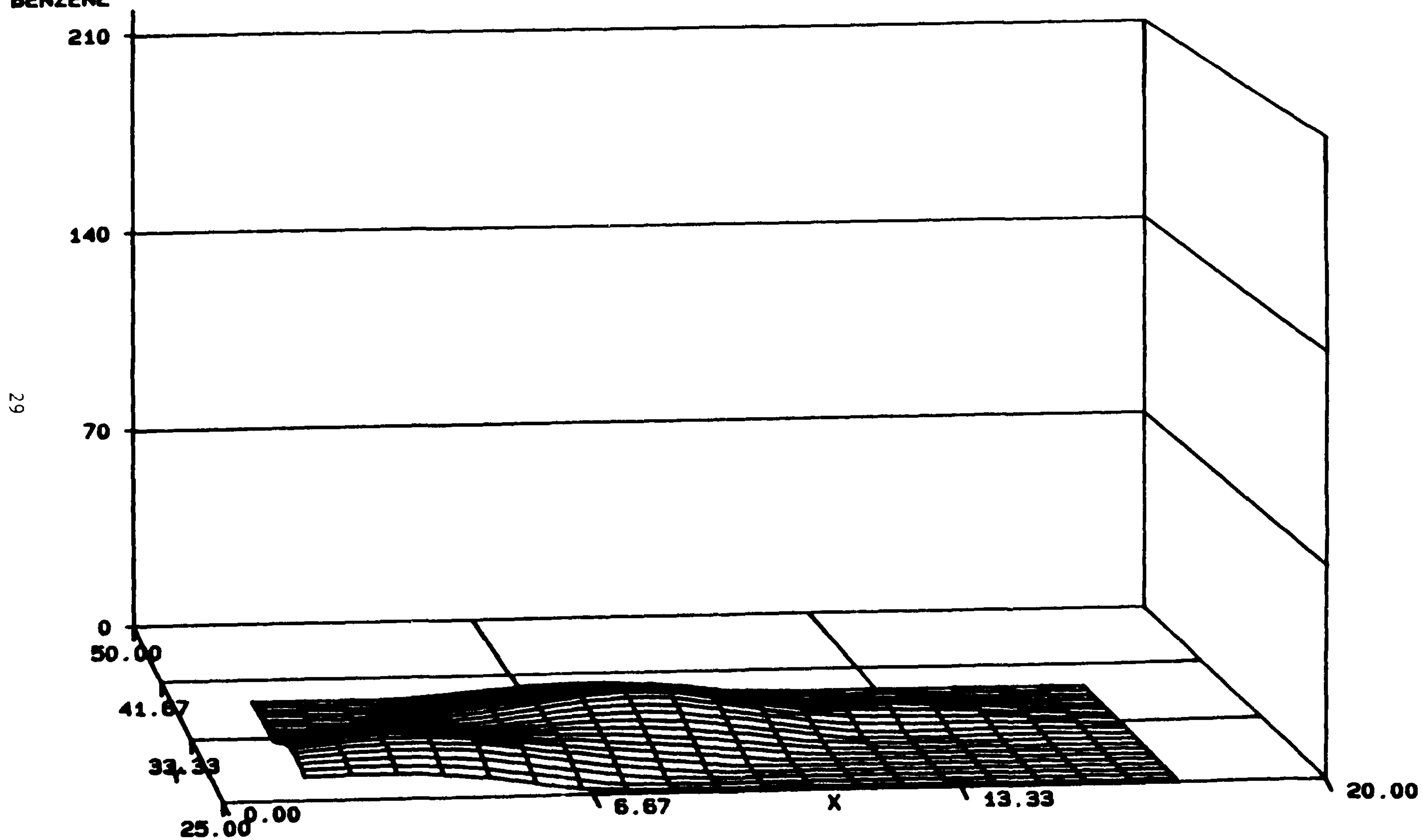
Concentration measured in ug/l
x and y are relative longitude and latitude, respectively

Source: USGS (Report unavailable)

Figure 12a

Spatial Distribution of Benzene

Northern Landfill Area – 1980



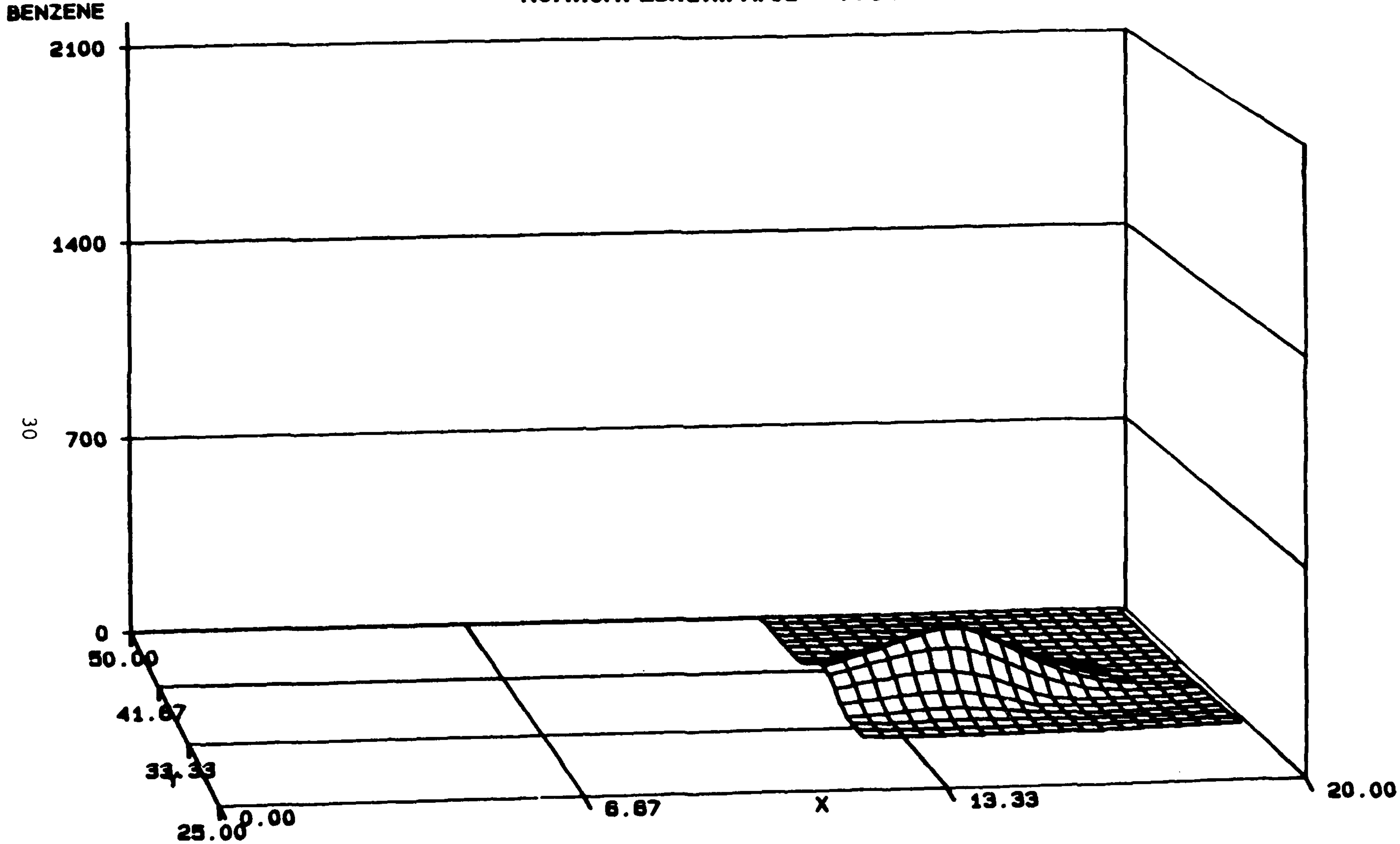
Benzene concentration measured in ug/l
x and y are relative longitude and latitude, respectively

Source: USGS Water Resource Investigations Report 83–4002

Figure 12b

Spatial Distribution of Benzene

Northern Landfill Area — 1984



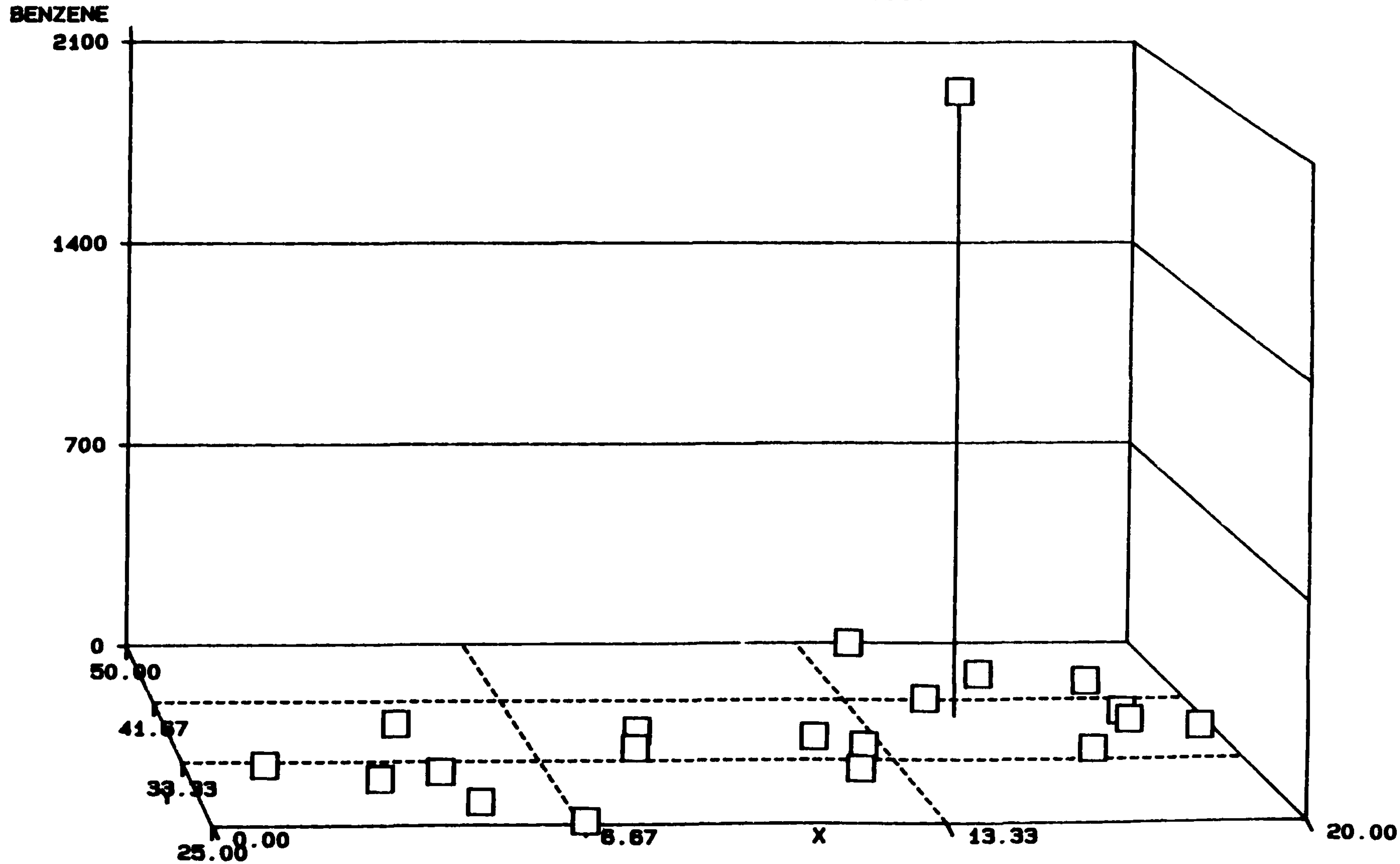
Benzene concentration measured in ug/l
x and y are relative longitude and latitude, respectively

Source: USGS Water Resource Investigations Report 86–4188

FIGURE 12c

SPATIAL DISTRIBUTION OF BENZENE

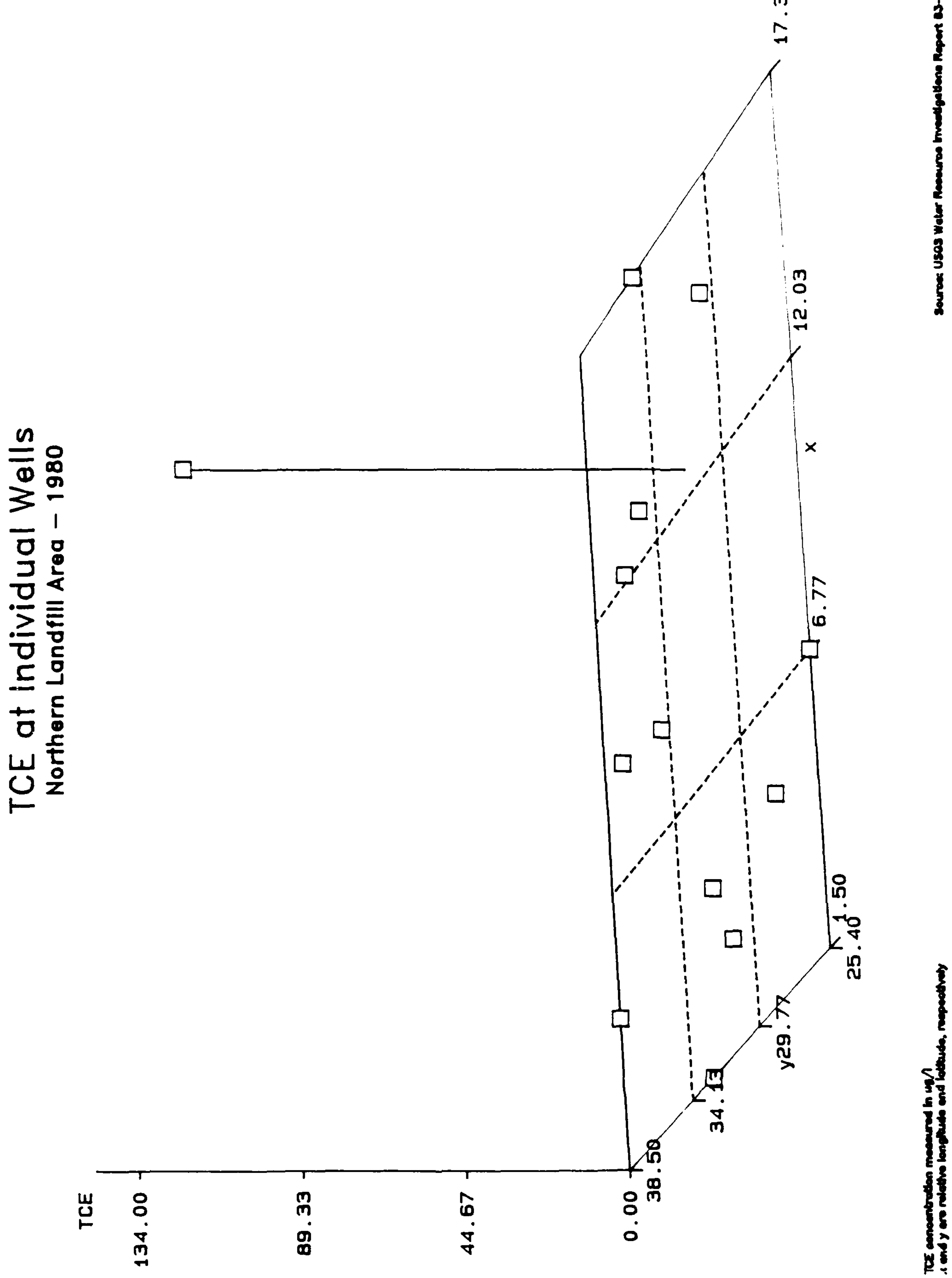
NORTHERN LANDFILL AREA – 1987



BENZENE CONCENTRATION MEASURED IN UG/L
X AND Y ARE LONGITUDE AND LATITUDE

SOURCE: USGS (REPORT UNAVAILABLE)

FIGURE 13a

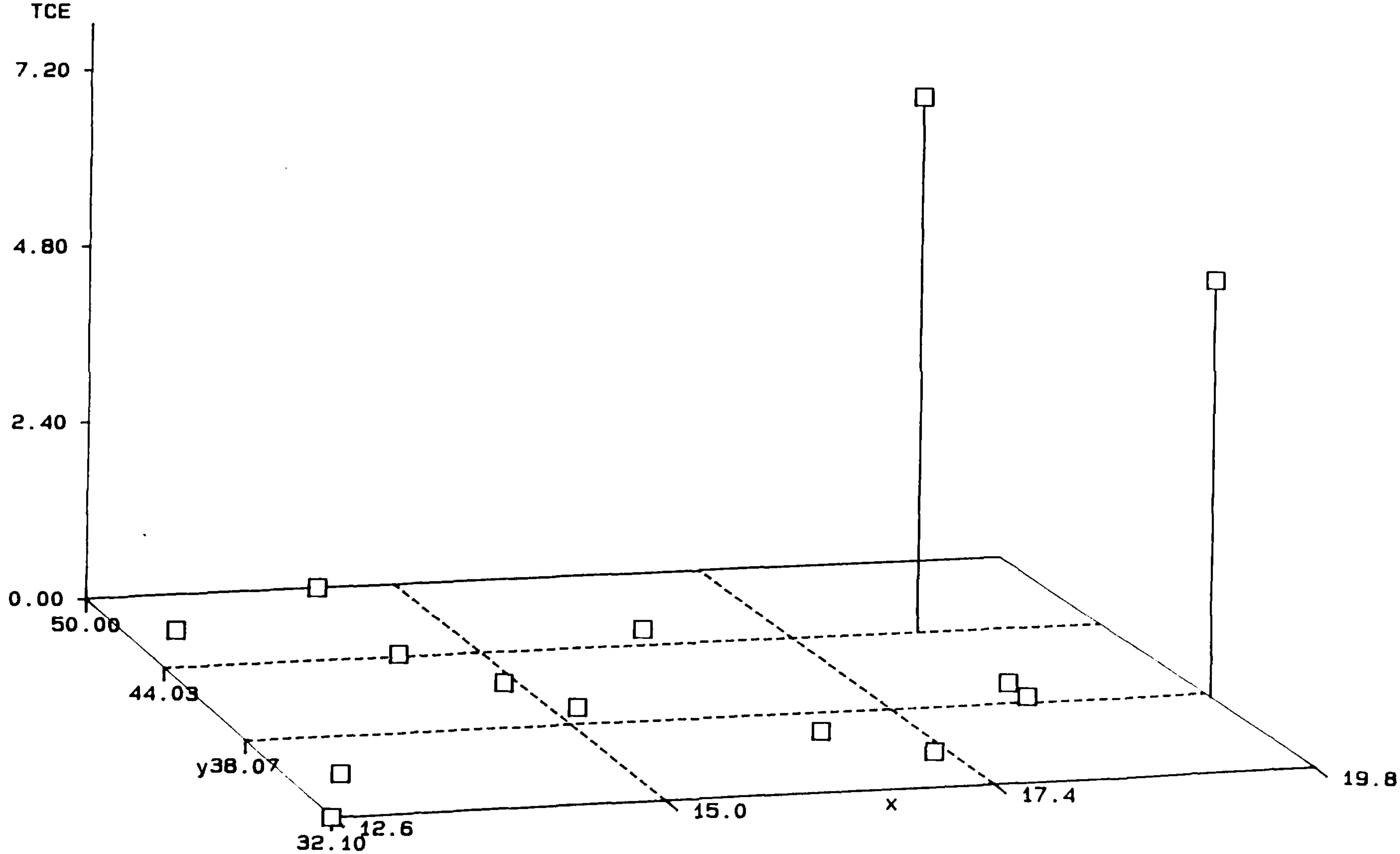


TCE at Individual Wells
Northern Landfill Area – 1980
TCE
134.00
89.33
44.67
0.00
38.50
34.13
y29.77
25.40
1.50
6.77
x
12.03
17.30
Source: USGS Water Resource Investigations Report 83-4002
TCE concentration measured in ug/l
x and y are relative longitude and latitude, respectively

FIGURE 13b

TCE at Individual Wells

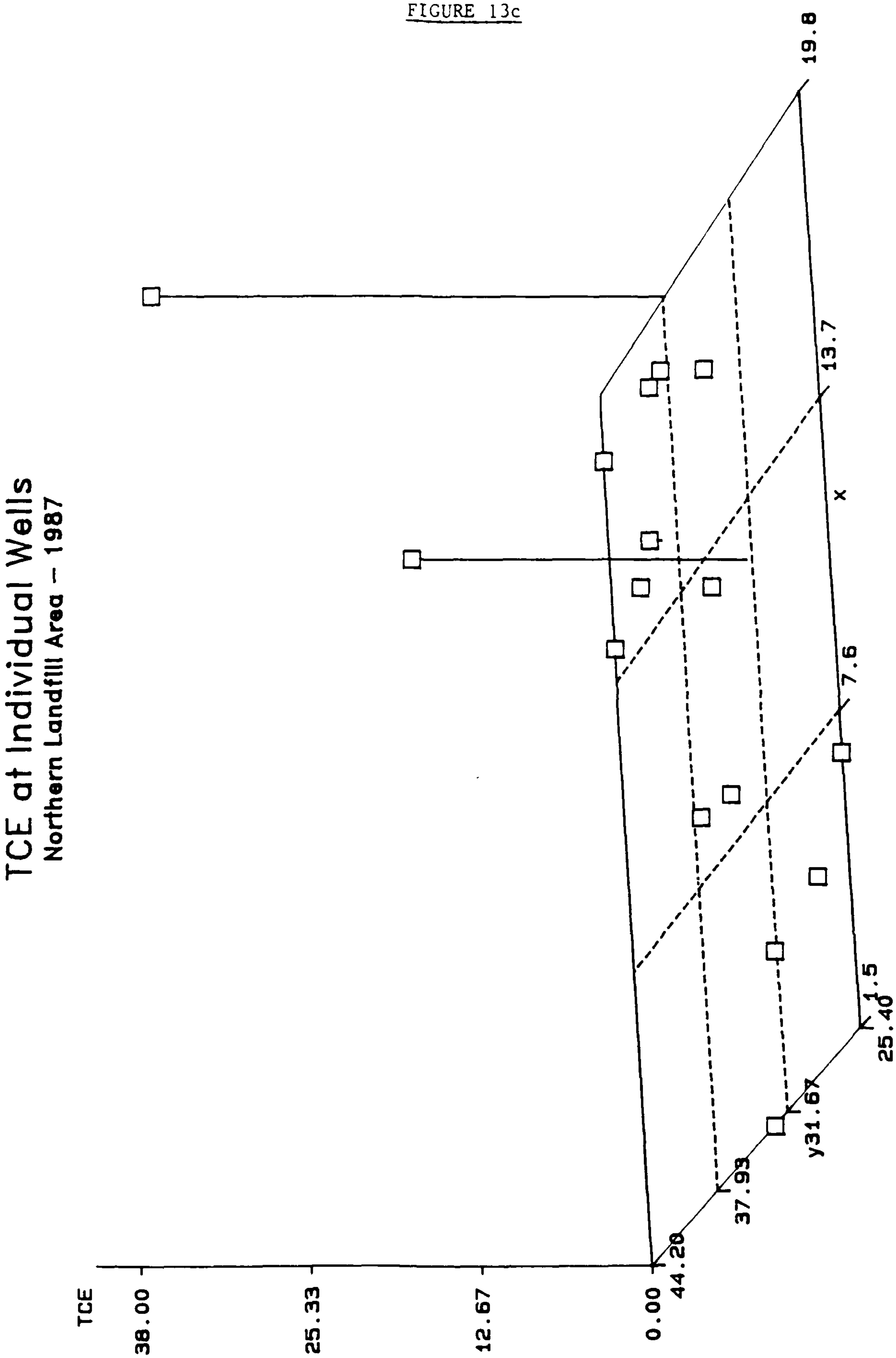
Northern Landfill Area – 1984



TCE concentration measured in ug/l
x and y are relative longitude and latitude, respectively

Source: USGS Water Resource Investigations Report 83-4002

FIGURE 13c



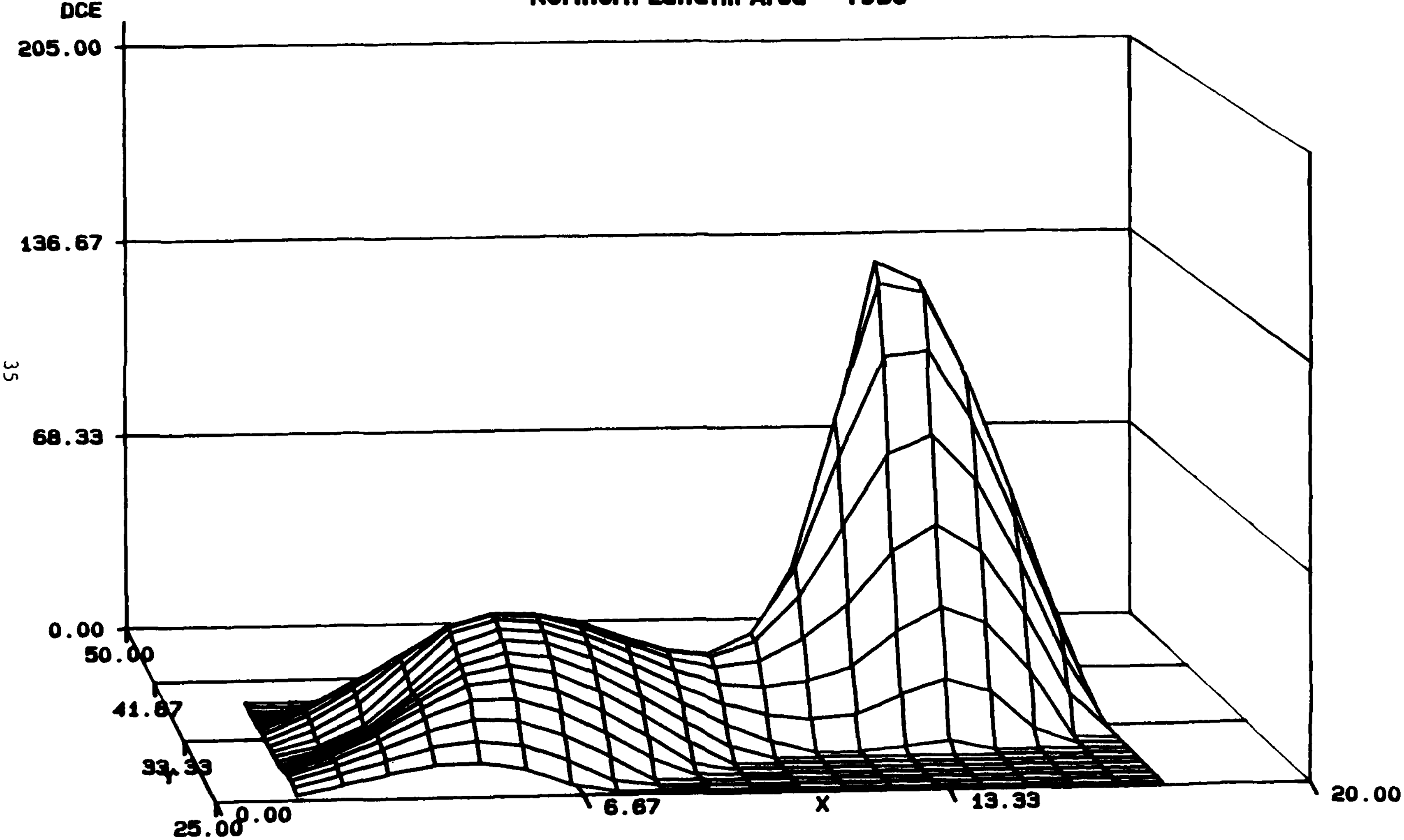
TCE concentration measured in ug/l
x and y are relative longitude and latitude, respectively

Source: USGS (Report unavailable)

Figure 14a

Spatial Distribution of DCE

Northern Landfill Area – 1980



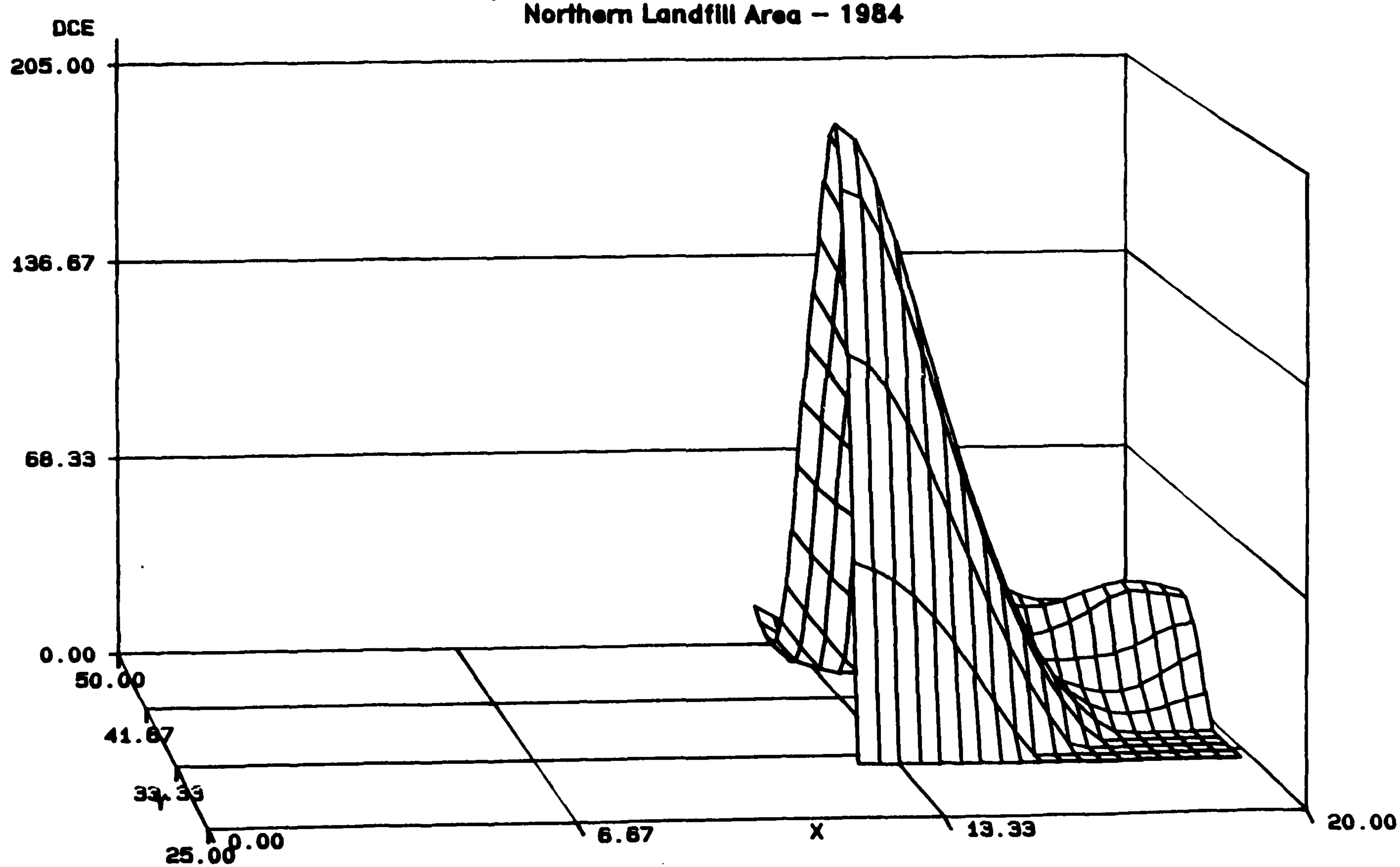
DCE concentration measured in ug/l
x and y are relative longitude and latitude, respectively

Source: USGS Water Resource Investigations Report 83–4002

Figure 14b

Spatial Distribution of DCE

Northern Landfill Area – 1984



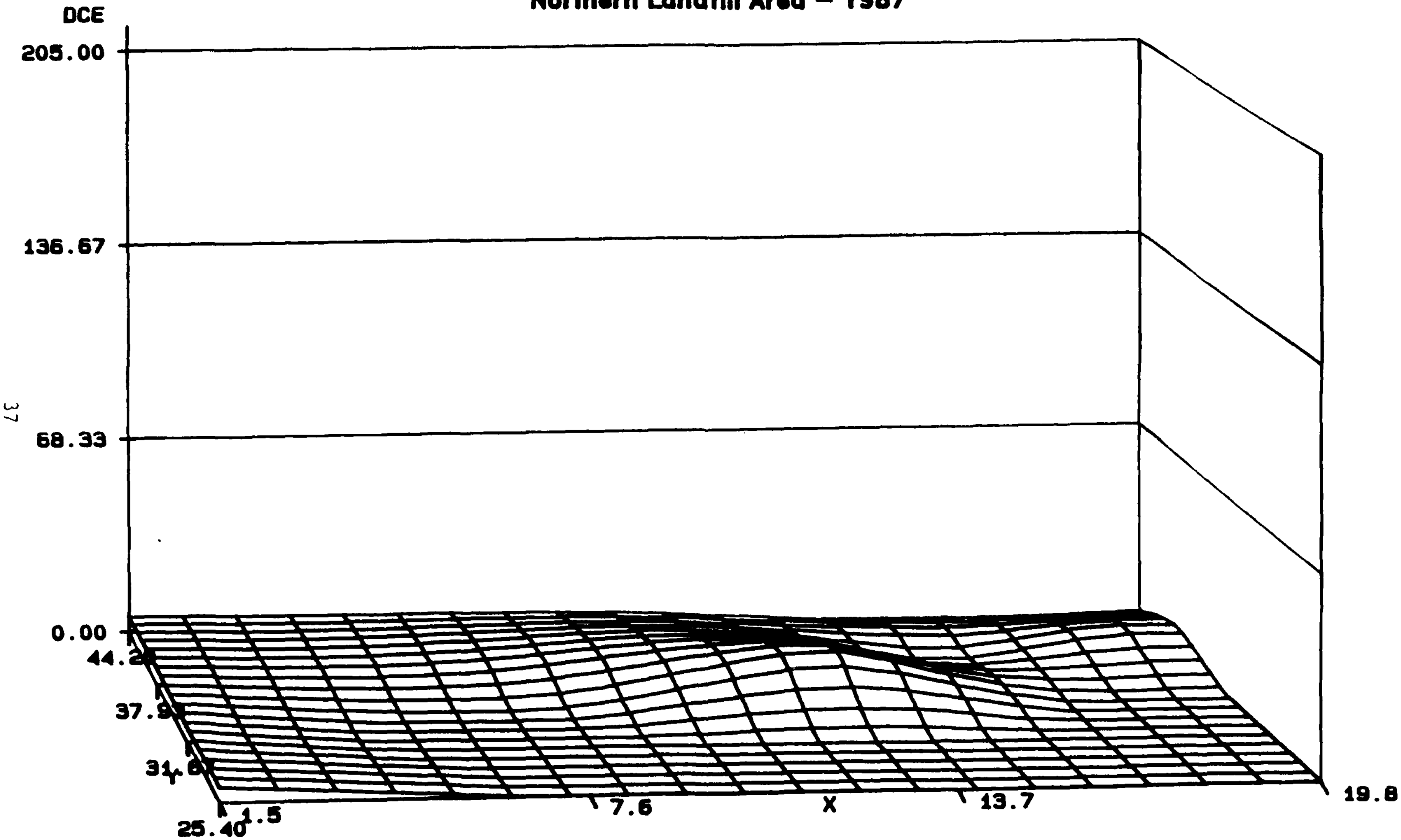
DCE concentration measured in ug/l
x and y are relative longitude and latitude, respectively

Source: USGS Water Resource Investigations Report 86–4188

Figure 14c

Spatial Distribution of DCE

Northern Landfill Area – 1987



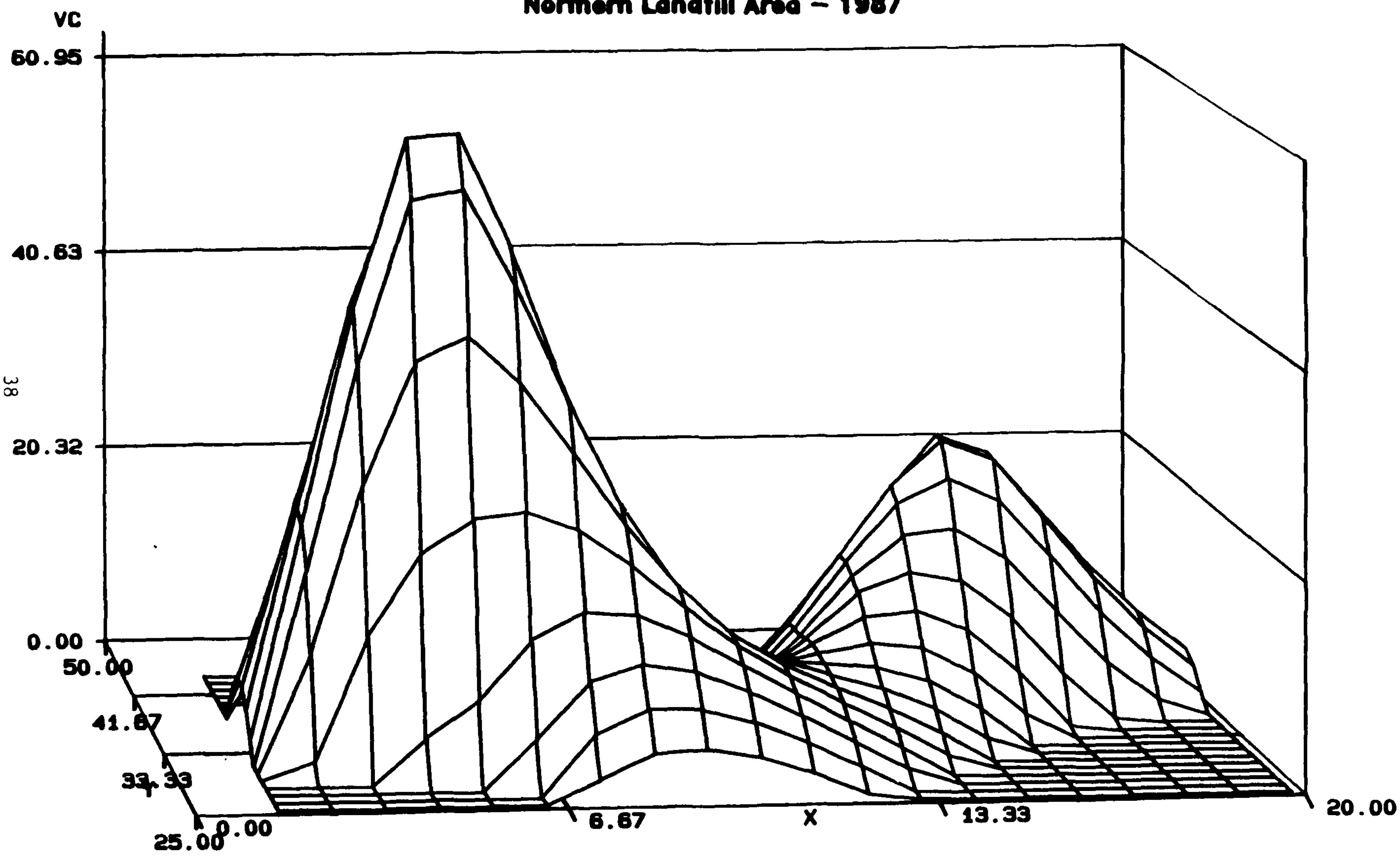
DCE concentration measured in ug/l
x and y are relative longitude and latitude, respectively

Source: USGS (Report unavailable)

Figure 15

Spatial Distribution of Vinyl Chloride

Northern Landfill Area – 1987



Vinyl chloride concentration measured in ug/l
x and y are relative longitude and latitude, respectively

Source: USGS (Report unavailable)

However, these levels are known not to be representative of the plume in wells immediately surrounding well H78S and are thus considered anomalous. It is believed that a small local spill of a fuel product within the immediate vicinity of well H78S and perhaps a dumping of such product actually down the unsecured well could account for the anomalously high benzene levels. Because of the anomalous benzene data in 1987, a spline surface was not fit to the data (Figure 12c). This would have misrepresented the actual levels of known benzene by projecting high levels beyond the influence of well H78S in areas of minor contamination.

Relatively high concentrations of TCE have been reported at only three wells: well O4S in the landfill region at 130 µg/L in 1980 and 20 µg/L in 1987; well H75S on the shore of Van Etten Lake at 7 µg/L in 1984 and 12 µg/L in 1987; and well H33S, also on the shore of Van Etten Lake, at 5 µg/L in 1984 (see Figures 13a,b,c). Thus, TCE seems to be the least pervasive contaminant of interest in the Northern Landfill area.

Figures 14a and 14b portray a fairly stable distribution of DCE for the 1980 and 1984 measurement periods, with peaks of about 150 µg/L near well R89S just outside the eastern boundary of Wurtsmith AFB. Notice that because the USGS sampled mostly from wells to the east of Wurtsmith AFB in 1984, Figure 14b portrays only that part of the distribution. The spatial distribution for 1987 (Figure 14c) shows a dramatic decrease to about 15 µg/L at the center (well R89S) of the DCE plume although the levels are still higher than the action limits east of the center.

When the USGS began reporting vinyl chloride in 1987, this contaminant was quickly recognized as being quite pervasive. It attained a peak concentration of close to 60 µg/L near well R16S with a secondary peak of 20 µg/L near well R78S. Figure 15 illustrates the estimated spatial distribution of vinyl chloride throughout the shallow levels of the aquifer.

Depth analysis

For all of the contaminants, the levels found in the deep wells were always less than the levels in their shallow counterparts. In the case of TCE, there were none detected by the USGS in any of the deep wells at any time (although the USAF did detect 10.0 µg/L TCE at well R88D in 1985). For the other three contaminants, there are detectable levels in the deep wells, frequently above the action levels, and occasionally quite high (e.g., 155 µg/L of DCE at well R88D on 2 March 1981).

Conclusions

All of the conclusions that we shall make are tentative in the sense that they are not formally confirmed by a scientifically rigorous experiment designed to test these specific conclusions. Time and cost prohibit the undertaking of such an experiment. Rather, our conclusions are suggested by the preponderance of data available. For each conclusion, we cite the specific analyses suggesting it.

Likely sources of contamination

For the Alert Apron area, the most likely scenario is a one-time spill in the 1970s of about 3-5 barrels of TCE near the waste storage area. We believe that there is no continuous source for the Alert Apron plume because all the TCE levels in wells in the western half of the plume have decreased in TCE concentration from 1980 to 1986. Well R36S in the west central area of the original plume has shown a statistically significant steadily downward trend, and well R34S in the east central area of the plume has also shown a downward trend with one minor perturbation that can be explained by the migration of the last slug of TCE. Finally, Figures 3a and 3b portray the type of spatial migration to be expected from a one-time release from the waste storage area.

Estimates of the size and time of the release were obtained using the solute transport model "SOLUTE" [Beljin, 1985]. The rate at which TCE levels dropped in all the wells by the western edge of the plume is also consistent with that predicted by the model for a single release of 3-5 barrels of TCE under conditions corresponding to the geological parameters of the Alert Apron area.

An obvious anomaly for the Alert Apron plume is the area of highest TCE concentration centered near Pierce's well. Under normal conditions the concentration of an unsaturated solute will not increase downgradient of its source. The anomaly suggests the possibility of a second source of TCE located off Wurtsmith base near Pierce's well. Other circumstances could also explain this anomaly; however, with the data available at this time, we cannot rule out the possibility of a second source of TCE located off base.

One possibility for a second source would be the use of TCE to clean a septic tank located about 60 feet west of Pierce's well. Some of this may have leaked and contaminated the water in the well. Another possibility is that large deposits of organic material from the septic tank act as a filter trapping TCE, explaining its appearance in higher than expected concentrations. Further testing is needed to resolve the issue. On August 12, 1987 the Occupational and Environmental Health Laboratory requested that shallow and deep monitoring wells be constructed just upgradient of Pierce's well.

The source for the chemical constituents reported at the Northern Landfill plume appears to be the landfill itself. However, as illustrated in Figure 12c, anomalously high levels of benzene detected at Camp Nissokone are not necessarily related to the landfill and could be explained by a small local source located near well H78S.

Adequacy of this data as a basis for risk assessment

All three agencies that collected data agree fairly closely about concentration of TCE measured at the same wells during the same year (see the section entitled Source bias). The widespread sampling by these agencies suggests that the maximum observed value for each contaminant is a credible estimate of maximal possible exposure. Thus, use of the largest observed values for each contaminant should lead to accurate estimates of maximal risk. Because the major and perhaps only, risk to humans at the observed levels of concentration is through drinking [Jones, 1987], the best estimates of actual exposure come from monitoring drinking wells. According to an August 11, 1987 USAF laboratory report, the only detectible contamination at any of the drinking wells near the two plumes is at Pierce's well, which is no longer used for drinking.

Remedial Action Alternatives

In the Alert Apron plume, the time for restoration of all areas to concentrations of TCE below action levels is estimated to be less than 10 years if no action is taken. It is critical that the anomalously high levels of TCE found in the Pierce's well vicinity be further investigated before the need for active remediation can be assessed.

The need for or the cost effectiveness of a pump-and-treat remedial program at the Alert Apron plume is not clear at this time. The level of cleanup, however, will not be any greater than that rendered by natural purging via groundwater discharge to Van Etten Lake.

If a pump-and-treat program is entertained as a remedial alternative at the Northern Landfill plume, further investigation to explain the benzene anomaly will be necessary. A detailed analysis of the cost and technical effectiveness of this remedial alternative has not been conducted. Any treatment at this site should be preceded by further exploration to locate the source precisely.

Preliminary testing at the YMCA camp drinking wells nearest this plume (USAF, 5 Aug 1987) shows no sign of contamination. Considering the potential health risk, however, the drinking water supply wells and selected monitoring wells located on the camp property should be monitored on a routine basis to safeguard against potential migration of contamination.

If remediation near the YMCA camp does prove necessary, a shallow well purge system along the southern border of the YMCA camp may be effective as a temporary measure to divert the plume from the YMCA wells. Contaminated water extracted from the purge system could be dispersed at the landfill site by a spray-irrigation system, provided that the system is acceptable to the applicable regulatory agencies. An air quality permit from the State of Michigan Air Quality Board would be needed before this plan could be adopted.

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APPENDIX A

ALERT APRON DATA

This appendix contains a listing of all of the data collected from the monitoring wells in the Alert Apron area. Variables which are included are well identification number (deep wells have a suffix "D" and shallow wells have a suffix "S"), date, date2 (expressed as a year and the fractional part of the year), TCE concentration, DCE concentration, benzene concentration, PCE concentration, and the data group (indicating the source of the data).

ALERT APRON PLUME (PIERCE's PLUME)

WELL	DATE1	DATE2	TCE	DCE	BEN	PCE	DATAGRP
AF22	31JAN80	80.085	15.000	ND	ND	ND	2
AF22	05AUG87	87.594	ND	ND	ND	ND	1
PIERCE	27JUN79	79.488	795.000	ND	ND	ND	1
PIERCE	05JUL79	79.510	750.000	ND	ND	ND	1
PIERCE	22MAY80	80.388	462.000	ND	ND	ND	2
PIERCE	04JUN84	84.423	390.000	ND	ND	ND	1
PIERCE	11JUN84	84.443	205.000	ND	ND	ND	1
PIERCE	18JUN84	84.462	414.000	ND	ND	ND	1
PIERCE	25JUN84	84.481	414.000	ND	ND	ND	1
PIERCE	02JUL84	84.500	274.000	ND	ND	ND	1
PIERCE	09JUL84	84.519	422.000	ND	ND	ND	1
PIERCE	16JUL84	84.538	430.000	ND	ND	ND	1
PIERCE	23JUL84	84.557	430.000	ND	ND	ND	1
PIERCE	30JUL84	84.576	458.000	ND	ND	ND	1
PIERCE	06AUG84	84.596	465.000	ND	ND	ND	1
PIERCE	13AUG84	84.615	432.000	ND	ND	ND	1
PIERCE	20AUG84	84.634	425.000	ND	ND	ND	1
PIERCE	05SEP84	84.678	516.000	ND	ND	ND	1
PIERCE	04JUN85	85.425	440.000	ND	ND	ND	1
PIERCE	02JUL85	85.501	366.000	ND	ND	ND	1
PIERCE	19AUG85	85.633	1001.000	ND	ND	ND	1
PIERCE	03SEP85	85.674	1281.000	ND	ND	ND	1
PIERCE	12MAY86	86.362	28.100	ND	ND	ND	1
PIERCE	02JUN86	86.420	448.000	ND	ND	ND	1
PIERCE	30JUN86	86.496	176.000	ND	ND	ND	1
PIERCE	05AUG86	86.595	215.600	ND	ND	ND	1
PIERCE	09SEP86	86.690	377.000	ND	ND	ND	1
PIERCE	29SEP86	86.745	424.000	ND	ND	ND	1
PIERCE	03JUN87	87.422	480.000	ND	ND	ND	4
PIERCE	16JUN87	87.458	284.000	ND	ND	ND	5
PIERCE	05AUG87	87.594	424.000	ND	ND	ND	1
R1D	07NOV86	86.852	ND	ND	ND	ND	5
R1D	23APR87	87.310	ND	ND	ND	ND	5
R1D(1)	19MAY87	87.381	ND	ND	ND	ND	5
R1D(2)	20MAY87	87.384	ND	ND	ND	ND	4
R1S	07NOV86	86.852	ND	ND	ND	ND	5
R1S(3)	19MAY87	87.381	ND	ND	ND	ND	5
R1S(4)	20MAY87	87.384	0.200	ND	ND	ND	4
R2D	20DEC79	79.970	ND	ND	ND	ND	2
R2D	10JAN80	80.027	ND	ND	ND	ND	2
R2S	20DEC79	79.970	ND	ND	ND	ND	2
R2S	10JAN80	80.027	ND	ND	ND	ND	2
R12D	20DEC79	79.970	ND	ND	ND	ND	2
R12D	10JAN80	80.027	ND	ND	ND	ND	2
R12D	25JAN82	82.068	ND	ND	ND	ND	1
R12D	02FEB82	82.090	ND	ND	ND	ND	1
R12D	08FEB82	82.107	ND	ND	ND	ND	1
R12D	22FEB82	82.145	ND	ND	ND	ND	1
R12D	19APR82	82.299	ND	ND	ND	ND	1

R12D	21JUN82	82.471	ND	ND	ND	ND	1
R12D	26JUL82	82.567	ND	ND	ND	ND	1
R12D	09AUG82	82.605	ND	ND	ND	ND	1
R12D	20SEP82	82.721	ND	ND	ND	ND	1
R12D	12OCT82	82.781	ND	ND	ND	ND	1
R12D	18OCT82	82.797	ND	ND	ND	ND	1
R12D	15NOV82	82.874	ND	ND	ND	ND	1
R12D	18APR83	83.296	ND	ND	ND	ND	1
R12D	31MAY83	83.414	ND	ND	ND	ND	1
R12D	20JUN83	83.468	0.200	ND	ND	ND	1
R12D	25JUL83	83.564	0.300	ND	ND	ND	1
R12D	08AUG83	83.603	3.700	ND	ND	ND	1
R12D	11OCT83	83.778	0.200	ND	ND	ND	1
R12D	17OCT83	83.795	ND	ND	ND	ND	1
R12D	05MAR84	84.175	0.200	ND	ND	ND	1
R12D	16APR84	84.290	ND	ND	ND	ND	1
R12D	30JUL84	84.577	0.400	ND	ND	ND	1
R12D	15OCT84	84.787	ND	ND	ND	ND	1
R12D	25MAR85	85.230	ND	ND	ND	ND	1
R12D	15APR85	85.288	1.200	ND	ND	ND	1
R12D	29JUL85	85.575	ND	ND	ND	ND	1
R12D	04NOV85	85.844	ND	ND	ND	ND	1
R12D	21JAN86	86.058	ND	ND	ND	ND	1
R12D	19MAY86	86.381	1.2	ND	ND	ND	1
R12D	09MAR87	87.186	ND	ND	ND	ND	1
R12D	16MAR87	87.205	ND	ND	ND	ND	1
R12D	20APR87	87.301	ND	ND	ND	ND	1
R13D	20DEC79	79.970	ND	ND	ND	ND	2
R13D	10JAN80	80.028	ND	ND	ND	ND	2
R13D	31JAN80	80.085	ND	ND	ND	ND	2
R13D	13AUG80	80.617	ND	ND	ND	ND	2
R13D	10APR84	84.273	ND	ND	ND	ND	3
R13D	17JUN85	85.460	ND	ND	ND	ND	1
R13D(5)	20MAY87	87.384	ND	ND	ND	1.000	4
R13S(6)	11JUN80	80.443	13.000	ND	ND	ND	2
R13S	11JUN80	80.443	12.000	ND	ND	ND	2
R13S	13AUG80	80.615	12.000	ND	ND	ND	2
R13S	07NOV86	86.852	1.100	ND	ND	200.000	5
R13S	03MAR87	87.170	ND	ND	ND	130.000	5
R13S(7)	20MAY87	87.384	1.400	ND	ND	420.000	4
R19D	01MAY80	80.331	10.000	ND	ND	ND	2
R19D	23MAY80	80.391	6.100	ND	ND	ND	2
R19D	14AUG80	80.617	ND	ND	ND	ND	2
R19D	11APR84	84.276	7.600	ND	ND	ND	3
R19D	07NOV86	86.852	3.900	ND	ND	ND	5
R19D	03MAR87	87.170	ND	ND	ND	ND	5
R19D(8)	19MAY87	87.381	5.100	ND	ND	ND	4
R19S	01MAY80	80.331	291.000	ND	ND	ND	2
R19S	23MAY80	80.391	247.000	ND	ND	ND	2
R19S	12JUN80	80.445	282.000	ND	ND	ND	2
R19S	14AUG80	80.617	250.000	ND	ND	ND	2
R19S	25JAN82	82.068	1.000	.	.	.	1
R19S	19APR82	82.299	3.400	.	.	.	1
R19S	26JUL82	82.567	ND	.	.	.	1
R19S	19OCT82	82.800	ND	.	.	.	1

R19S	24JAN83	83.066	ND	.	.	.	1
R19S	18APR83	83.296	ND	.	.	.	1
R19S	25JUL83	83.564	0.200	.	.	.	1
R19S	17OCT83	83.795	1.700	.	.	.	1
R19S	13FEB84	84.120	ND	.	.	.	1
R19S	16APR84	84.290	0.300	.	.	.	1
R19S	23JUL84	84.557	1.600	.	.	.	1
R19S	15OCT84	84.787	60.300	.	.	.	1
R19S	04FEB85	85.099	252.000	.	.	.	1
R19S	15APR85	85.288	99.000	.	.	.	1
R19S	22JUL85	85.556	79.000	.	.	.	1
R19S	21JAN86	86.058	ND	.	.	.	1
R19S	20APR86	86.301	ND	ND	ND	ND	1
R19S	21APR86	86.304	98.300	.	.	.	1
R19S	05MAY86	86.342	103.200	.	.	.	1
R19S	07NOV86	86.852	460.000	.	.	.	1
R19S	07NOV86	86.852	460.000	ND	ND	ND	5
R19S	02MAR87	87.167	ND	.	.	.	1
R19S(9)	19MAY87	87.381	370.000	ND	ND	ND	4
R19S(10)	19MAY87	87.381	270.000	ND	ND	ND	5
R20D	02MAY80	80.337	ND	ND	ND	ND	2
R21S	02MAY80	80.337	ND	ND	ND	ND	2
R27D	01MAY80	80.331	1.000	ND	ND	ND	2
R27D	22MAY80	80.391	ND	3.000	ND	ND	2
R27D	14AUG80	80.617	2.000	ND	ND	ND	2
R27D	10APR84	84.276	ND	ND	ND	ND	3
R27D	23APR87	87.310	6.400	ND	ND	ND	1
R27D	23APR87	87.310	6.200	ND	ND	ND	5
R27D	19MAY87	87.381	12.000	ND	ND	ND	4
R27D	19MAY87	87.381	11.000	ND	ND	ND	5
R27S	12JUN80	80.445	2.000	ND	ND	ND	2
R27S	14AUG80	80.617	ND	ND	ND	ND	2
R27S	23APR87	87.310	51.600	ND	ND	ND	1
R27S	23APR87	87.310	51.000	ND	ND	ND	5
R27S	19MAY87	87.381	54.000	ND	ND	ND	4
R27S	19MAY87	87.381	46.000	ND	ND	ND	5
R28S	12JUN80	80.445	ND	ND	ND	ND	2
R28S	14AUG80	80.617	ND	ND	ND	ND	2
R28S	23APR87	87.310	0.600	ND	ND	ND	1
R28S	23APR87	87.310	ND	ND	ND	ND	5
R28S(11)	19MAY87	87.381	13.000	ND	ND	ND	4
R29S	11JUN80	80.445	169.000	ND	ND	ND	2
R29S	13AUG80	80.617	265.000	ND	ND	ND	2
R29S	11APR84	84.276	20.000	ND	ND	ND	3
R29S	03MAR87	87.170	5.100	ND	ND	ND	5
R29S	19MAY87	87.381	12.000	ND	ND	ND	4
R30S	11JUN80	80.445	13.000	ND	ND	157.000	2
R30S	11JUN80	80.445	18.000	ND	ND	.	2
R30S	13AUG80	80.617	64.000	ND	ND	ND	2
R31S	12JUN80	80.445	ND	ND	ND	ND	2
R31S	14AUG80	80.617	ND	ND	ND	ND	2
R31S	19MAY87	87.381	0.200	ND	ND	ND	4
R32S	03MAR87	87.170	41.000	ND	ND	ND	5
R32S(12)	19MAY87	87.381	43.000	ND	ND	ND	5
R32S	20MAY87	87.384	46.000	ND	ND	ND	4

R33S	12JUN80	80.445	9.000	ND	ND	ND	2
R33S	14AUG80	80.617	ND	ND	ND	ND	2
R34S	11JUN80	80.445	215.000	ND	ND	ND	2
R34S	13AUG80	80.617	217.000	ND	ND	ND	2
R34S	27APR81	81.321	58.400	ND	ND	ND	1
R34S	18MAY81	81.378	70.000	ND	ND	ND	1
R34S	22JUN81	81.474	73.500	ND	ND	ND	1
R34S	27JUL81	81.570	76.200	ND	ND	ND	1
R34S	17AUG81	81.627	88.300	ND	ND	ND	1
R34S	21SEP81	81.723	76.000	ND	ND	ND	1
R34S	26OCT81	81.819	48.000	ND	ND	ND	1
R34S	16NOV81	81.877	48.100	ND	ND	ND	1
R34S	21DEC81	81.973	32.500	ND	ND	ND	1
R34S	25JAN82	82.068	31.500	ND	ND	ND	1
R34S	22FEB82	82.145	26.300	ND	ND	ND	1
R34S	22MAR82	82.222	36.500	ND	ND	ND	1
R34S	05APR82	82.260	46.000	ND	ND	ND	1
R34S	03MAY82	82.337	52.000	ND	ND	ND	1
R34S	02JUN82	82.419	67.000	ND	ND	ND	1
R34S	28JUN82	82.490	64.700	ND	ND	ND	1
R34S	26JUL82	82.567	50.6000	ND	ND	ND	1
R34S	23AUG82	82.644	144.000	ND	ND	ND	1
R34S	20SEP82	82.721	31.300	ND	ND	ND	1
R34S	04OCT82	82.759	30.300	ND	ND	ND	1
R34S	09NOV82	82.858	34.600	ND	ND	ND	1
R34S	29NOV82	82.912	28.900	ND	ND	ND	1
R34S	27DEC82	82.989	21.900	ND	ND	ND	1
R34S	24JAN83	83.066	21.200	ND	ND	ND	1
R34S	22FEB83	83.145	16.400	ND	ND	ND	1
R34S	07MAR83	83.181	ND	ND	ND	ND	1
R34S	14MAR83	83.200	ND	ND	ND	ND	1
R34S	02MAY83	83.334	24.200	ND	ND	ND	1
R34S	31MAY83	83.414	112.000	ND	ND	ND	1
R34S	27JUN83	83.488	42.900	ND	ND	ND	1
R34S	25JUL83	83.564	58.400	ND	ND	ND	1
R34S	22AUG83	83.641	20.300	ND	ND	ND	1
R34S	19SEP83	83.718	37.900	ND	ND	ND	1
R34S	03OCT83	83.756	44.600	ND	ND	ND	1
R34S	31OCT83	83.833	40.800	ND	ND	ND	1
R34S	28NOV83	83.910	30.200	ND	ND	ND	1
R34S	27DEC83	83.989	ND	ND	ND	ND	1
R34S	31JAN84	84.085	3.900	ND	ND	ND	1
R34S	22FEB84	84.145	2.900	ND	ND	ND	1
R34S	19MAR84	84.213	1.100	ND	ND	ND	1
R34S	09APR84	84.270	6.200	ND	ND	ND	1
R34S	11APR84	84.276	31.000	ND	ND	11.000	3
R34S	07MAY84	84.347	22.000	ND	ND	ND	1
R34S	04JUN84	84.424	23.000	ND	ND	ND	1
R34S	25JUN84	84.481	22.000	ND	ND	ND	1
R34S	23JUL84	84.557	23.000	ND	ND	ND	1
R34S	20AUG84	84.634	17.000	ND	ND	ND	1
R34S	17SEP84	84.710	30.000	ND	ND	ND	1
R34S	01OCT84	84.749	15.500	ND	ND	ND	1
R34S	29OCT84	84.825	1.600	ND	ND	ND	1
R34S	26NOV84	84.902	24.400	ND	ND	ND	1

R34S	24DEC84	84.978	20.000	ND	ND	ND	1
R34S	21JAN85	85.058	25.000	ND	ND	ND	1
R34S	19FEB85	85.058	21.000	ND	ND	ND	1
R34S	18MAR85	85.211	29.000	ND	ND	ND	1
R34S	01APR85	85.249	52.000	ND	ND	ND	1
R34S	29APR85	85.326	19.000	ND	ND	ND	1
R34S	28MAY85	85.405	32.000	ND	ND	ND	1
R34S	24JUN85	85.479	30.000	ND	ND	ND	1
R34S	22JUL85	85.556	37.000	ND	ND	ND	1
R34S	19AUG85	85.633	40.000	ND	ND	ND	1
R34S	03SEP85	85.674	35.000	ND	ND	ND	1
R34S	23SEP85	85.729	22.000	ND	ND	ND	1
R34S	04NOV85	85.844	1.200	ND	ND	ND	1
R34S	16DEC85	85.959	18.100	ND	ND	ND	1
R34S	06JAN86	86.016	ND	ND	ND	ND	1
R34S	13JAN86	86.036	ND	ND	ND	ND	1
R34S	27JAN86	86.074	ND	ND	ND	ND	1
R34S	18FEB86	86.134	14.500	ND	ND	ND	1
R34S	03MAR86	86.170	34.900	ND	ND	ND	1
R34S	31MAR86	86.247	34.900	ND	ND	ND	1
R34S	05MAY86	86.342	65.200	ND	ND	ND	1
R34S	12MAY86	86.362	58.600	ND	ND	ND	1
R34S	23JUN86	86.477	86.000	ND	ND	ND	1
R34S	30JUN86	86.496	95.000	ND	ND	ND	1
R34S	29SEP86	86.745	56.000	ND	ND	ND	1
R34S	03NOV86	86.841	73.600	ND	ND	ND	1
R34S	07NOV86	86.852	96.000	ND	ND	1.800	5
R34S	08DEC86	86.937	ND	ND	ND	ND	1
R34S	05JAN87	87.014	84.300	ND	ND	ND	1
R34S	03FEB87	87.093	15.000	ND	ND	ND	1
R34S	02MAR87	87.167	ND	ND	ND	ND	1
R34S	30MAR87	87.244	ND	ND	ND	ND	1
R34S	05MAY87	87.342	85.000	ND	ND	ND	1
R34S(13)	20MAY87	87.384	92.000	ND	ND	5.200	4
R35S	11JUN80	80.445	ND	ND	ND	ND	2
R35S	13AUG80	80.617	ND	ND	ND	ND	2
R35S	03MAR87	87.170	3.900	ND	ND	ND	5
R35S(14)	20MAY87	87.384	2.900	ND	ND	ND	4
R36D	13AUG80	80.617	372.000	ND	ND	ND	2
R36D	10APR84	84.276	135.000	ND	ND	ND	3
R36D(15)	01SEP86	86.668	28.000	5.500	ND	ND	1
R36D	10SEP86	86.693	13.000	ND	ND	ND	1
R36D	15SEP86	86.707	32.000	ND	ND	ND	1
R36D(16)	22SEP86	86.726	17.000	ND	ND	ND	1
R36D	29SEP86	86.745	13.000	ND	ND	ND	1
R36D	07NOV86	86.852	22.000	ND	ND	ND	5
R36D	19MAY87	87.381	20.000	ND	ND	ND	5
R36D(17)	20MAY87	87.384	20.000	ND	ND	ND	4
R36S	11JUN80	80.445	387.000	ND	ND	ND	2
R36S	13AUG80	80.617	323.000	ND	ND	ND	2
R36S	17FEB81	81.132	76.000	ND	ND	ND	1
R36S	23MAR81	81.225	74.000	ND	ND	ND	1
R36S	27APR81	81.321	133.000	ND	ND	ND	1
R36S	18MAY81	81.378	159.000	ND	ND	ND	1
R36S	22JUN81	81.474	145.000	ND	ND	ND	1

R36S	27JUL81	81.570	136.000	ND	ND	ND	1
R36S	17AUG81	81.627	149.000	ND	ND	ND	1
R36S	21SEP81	81.723	138.000	ND	ND	ND	1
R36S	26OCT81	81.819	87.500	ND	ND	ND	1
R36S	16NOV81	81.877	76.400	ND	ND	ND	1
R36S	21DEC81	81.973	61.300	ND	ND	ND	1
R36S	25JAN82	82.068	56.300	ND	ND	ND	1
R36S	22FEB82	82.145	46.500	ND	ND	ND	1
R36S	22MAR82	82.222	115.000	ND	ND	ND	1
R36S	05APR82	82.260	107.000	ND	ND	ND	1
R36S	03MAY82	82.337	82.000	ND	ND	ND	1
R36S	02JUN82	82.419	109.000	ND	ND	ND	1
R36S	28JUN82	82.490	111.000	ND	ND	ND	1
R36S	26JUL82	82.567	99.000	ND	ND	ND	1
R36S	23AUG82	82.644	87.000	ND	ND	ND	1
R36S	20SEP82	82.721	58.700	ND	ND	ND	1
R36S	04OCT82	82.759	44.900	ND	ND	ND	1
R36S	09NOV82	82.858	66.800	ND	ND	ND	1
R36S	29NOV82	82.912	69.400	ND	ND	ND	1
R36S	27DEC82	82.989	26.400	ND	ND	ND	1
R36S	24JAN83	83.066	16.900	ND	ND	ND	1
R36S	22FEB83	83.145	18.000	ND	ND	ND	1
R36S	02MAY83	83.334	20.700	ND	ND	ND	1
R36S	31MAY83	83.414	25.400	ND	ND	ND	1
R36S	27JUN83	83.488	74.400	ND	ND	ND	1
R36S	25JUL83	83.564	60.300	ND	ND	ND	1
R36S	22AUG83	83.641	68.700	ND	ND	ND	1
R36S	19SEP83	83.718	45.700	ND	ND	ND	1
R36S	03OCT83	83.756	54.000	ND	ND	ND	1
R36S	17OCT83	83.795	20.900	ND	ND	ND	1
R36S	31OCT83	83.833	50.200	ND	ND	ND	1
R36S	28NOV83	83.910	40.700	ND	ND	ND	1
R36S	27DEC83	83.989	ND	ND	ND	ND	1
R36S	01FEB84	84.087	30.900	ND	ND	ND	1
R36S	22FEB84	84.145	20.400	ND	ND	ND	1
R36S	19MAR84	84.213	4.500	ND	ND	ND	1
R36S	09APR84	84.270	ND	ND	ND	ND	1
R36S	10APR84	84.276	65.000	ND	ND	ND	3
R36S	07MAY84	84.347	34.000	ND	ND	ND	1
R36S	04JUN84	84.424	49.000	ND	ND	ND	1
R36S	25JUN84	84.481	43.000	ND	ND	ND	1
R36S	30JUL84	84.577	39.000	ND	ND	ND	1
R36S	20AUG84	84.634	2.200	ND	ND	ND	1
R36S	17SEP84	84.710	0.300	ND	ND	ND	1
R36S	01OCT84	84.749	50.900	ND	ND	ND	1
R36S	29OCT84	84.825	14.000	ND	ND	ND	1
R36S	26NOV84	84.902	50.400	ND	ND	ND	1
R36S	24DEC84	84.978	20.000	ND	ND	ND	1
R36S	21JAN85	85.058	35.000	ND	ND	ND	1
R36S	19FEB85	85.137	38.000	ND	ND	ND	1
R36S	18MAR85	85.211	1.200	ND	ND	ND	1
R36S	01APR85	85.249	83.000	ND	ND	ND	1
R36S	29APR85	85.326	27.000	ND	ND	ND	1
R36S	28MAY85	85.405	28.000	ND	ND	ND	1
R36S	24JUN85	85.479	35.000	ND	ND	ND	1

R36S	22JUL85	85.556	41.000	ND	ND	ND	1
R36S	19AUG85	85.633	30.000	ND	ND	ND	1
R36S	03SEP85	85.674	25.000	ND	ND	ND	1
R36S	23SEP85	85.729	20.000	ND	ND	ND	1
R36S	04NOV85	85.844	2.200	ND	ND	ND	1
R36S	16DEC85	85.959	11.700	ND	ND	ND	1
R36S	13JAN86	86.036	ND	ND	ND	ND	1
R36S	04FEB86	86.096	10.500	ND	ND	ND	1
R36S	10MAR86	86.189	14.000	ND	ND	ND	1
R36S	31MAR86	86.247	22.900	ND	ND	ND	1
R36S	05MAY86	86.342	25.800	ND	ND	ND	1
R36S	19MAY86	86.381	26.200	ND	ND	ND	1
R36S	23JUN86	86.477	28.000	ND	ND	ND	1
R36S	30JUN86	86.496	34.000	ND	ND	ND	1
R36S	29SEP86	86.745	ND	ND	ND	ND	1
R36S	03NOV86	86.841	19.100	ND	ND	ND	1
R36S	07NOV86	86.852	16.100	ND	ND	ND	5
R36S	08DEC86	86.937	107.000	ND	ND	ND	1
R36S	05JAN87	87.014	20.200	ND	ND	ND	1
R36S	03FEB87	87.093	16.000	ND	ND	ND	1
R36S	02MAR87	87.167	ND	ND	ND	ND	1
R36S	03APR87	87.255	14.000	ND	ND	ND	1
R36S	05MAY87	87.342	24.000	ND	ND	ND	1
R36S	19MAY87	87.381	22.000	ND	ND	ND	5
R36S(18)	20MAY87	87.384	25.000	ND	0.200	ND	4
R37S	11JUN80	80.445	127.000	ND	ND	ND	2
R37S	13AUG80	80.618	169.000	ND	ND	16.000	2
R40S	14AUG80	80.617	30.000	ND	ND	ND	2
R41S	14AUG80	80.617	ND	ND	ND	ND	2
R42S	14AUG80	80.617	ND	ND	ND	ND	2
R42S	19MAY87	87.381	1.100	ND	ND	ND	5
R42S	20MAY87	87.384	0.200	ND	ND	ND	4
R44S	14AUG80	80.617	64.000	ND	ND	ND	2
R45S	14AUG80	80.617	ND	ND	ND	ND	2
R45S	19MAY87	87.381	ND	ND	ND	ND	4
R46S	14AUG80	80.617	186.000	ND	ND	ND	2
R46S(19)	01SEP86	86.668	ND	ND	ND	ND	1
R46S	10SEP86	86.693	ND	ND	ND	ND	1
R46S(20)	15SEP86	86.707	0.300	ND	ND	ND	1
R46S(21)	29SEP86	86.745	ND	ND	ND	ND	1
R46S	07NOV86	86.852	ND	ND	ND	ND	5
R46S	19MAY87	87.381	0.800	ND	ND	ND	4
R47S	14AUG80	80.617	33.000	ND	ND	ND	2
R47S(22)	01SEP86	86.668	ND	ND	ND	ND	1
R47S	10SEP86	86.693	ND	ND	ND	ND	1
R47S	15SEP86	86.707	0.300	ND	ND	ND	1
R47S(23)	22SEP86	86.726	0.300	ND	ND	ND	1
R47S	29SEP86	86.745	ND	ND	ND	ND	1
R47S	07NOV86	86.852	ND	ND	ND	ND	5
R47S	19MAY87	87.381	0.700	ND	ND	0.600	4
R48S(24)	19MAY87	87.381	6.100	ND	ND	ND	4
R49S	14AUG80	80.617	1000.000	ND	ND	ND	2
R49S	18SEP80	80.713	526.000	ND	ND	ND	2
R49S	15MAR82	82.203	107.000	ND	ND	ND	1
R49S	07JUN82	82.433	128.000	ND	ND	ND	1

R49S	07SEP82	82.685	47.300	ND	ND	ND	1
R49S	06DEC82	82.932	34.200	ND	ND	ND	1
R49S	07MAR83	83.181	71.000	ND	ND	ND	1
R49S	06JUN83	83.430	118.000	ND	ND	ND	1
R49S	12SEP83	83.699	64.200	ND	ND	ND	1
R49S	04MAR84	84.175	60.700	ND	ND	ND	1
R49S	10APR84	84.276	50.000	ND	ND	ND	3
R49S	04JUN84	84.426	60.000	ND	ND	ND	1
R49S	09SEP84	84.691	40.000	ND	ND	ND	1
R49S	16DEC84	84.959	33.000	ND	ND	ND	1
R49S	18MAR85	85.211	0.400	ND	ND	ND	1
R49S	04JUN85	85.425	26.000	ND	ND	ND	1
R49S	03SEP85	85.674	0.900	ND	ND	ND	1
R49S	03MAR86	86.170	ND	ND	ND	ND	1
R49S	09JUN86	86.438	24.000	ND	ND	ND	1
R49S(25)	07NOV86	86.852	24.000	ND	ND	ND	5
R49S	08DEC86	86.937	105.000	ND	ND	ND	1
R49S	02MAR87	87.167	ND	43.000	ND	ND	1
R49S(26)	19MAY87	87.381	22.000	ND	ND	0.300	4
R49S	08JUN87	87.436	22.000	ND	ND	ND	1
R50D	31OCT80	80.831	1.000	ND	ND	ND	2
R50S	14AUG80	80.617	1074.000	ND	ND	ND	2
R50S	18SEP80	80.713	1150.000	ND	ND	ND	2
R50S	31OCT80	80.831	867.000	ND	ND	ND	2
R51S	14AUG80	80.617	21.000	ND	ND	ND	2
R52S	14AUG80	80.617	19.000	ND	ND	ND	2
R54S	29OCT80	80.828	ND	ND	ND	ND	2
R54S	23APR87	87.310	ND	ND	ND	ND	5
R55S	29OCT80	80.828	274.000	ND	ND	ND	2
R55S(27)	07NOV86	86.852	41.000	ND	ND	ND	5
R55S(28)	03MAR87	87.170	5.900	ND	ND	ND	5
R55S(29)	19MAY87	87.381	68.000	ND	ND	0.400	4
R56S	28OCT80	80.825	6.700	ND	ND	ND	2
R56S	19MAY87	87.381	0.500	ND	ND	ND	4
R57S	28OCT80	80.825	2.400	ND	ND	ND	2
R58S	28OCT80	80.825	ND	ND	ND	ND	2
R58S	23APR87	87.310	ND	ND	ND	ND	5
R58S	19MAY87	87.381	0.500	ND	ND	ND	4
R59S	28OCT80	80.825	ND	ND	ND	ND	2
R59S	15MAR82	82.203	1.700	ND	ND	ND	1
R59S	07JUN82	82.433	ND	ND	ND	ND	1
R59S	06SEP82	82.685	2.500	ND	ND	ND	1
R59S	06DEC82	82.932	1.300	ND	ND	ND	1
R59S	07MAR83	83.181	72.000	ND	ND	ND	1
R59S	06JUN83	83.430	2.400	ND	ND	ND	1
R59S	12SEP83	83.699	0.700	ND	ND	ND	1
R59S	12DEC83	83.948	0.500	ND	ND	ND	1
R59S	05MAR84	84.175	0.300	ND	ND	ND	1
R59S	10APR84	84.276	ND	ND	ND	ND	3
R59S	04JUN84	84.424	ND	ND	ND	ND	1
R59S	10SEP84	84.691	ND	ND	ND	ND	1
R59S	17DEC84	84.959	0.400	ND	ND	ND	1
R59S	18MAR85	85.211	ND	ND	ND	ND	1
R59S	04JUN85	85.425	ND	ND	ND	ND	1
R59S	03SEP85	85.674	38.000	ND	ND	ND	1

R59S	07NOV86	86.852	ND	ND	ND	ND	5
R59S	03MAR87	87.170	ND	ND	ND	ND	5
R59S(30)	19MAY87	87.381	ND	ND	ND	ND	5
R59S	19MAY87	87.381	0.400	ND	ND	ND	4
R59S	08JUN87	87.436	ND	ND	ND	ND	1
R60S	29OCT80	80.825	12.000	ND	ND	ND	2
R62S	29OCT80	80.825	ND	ND	ND	ND	2
R63S	30OCT80	80.828	10.000	ND	ND	ND	2
R64S	30OCT80	80.828	5.500	ND	ND	ND	2
R65S	30OCT80	80.828	ND	ND	ND	ND	2
R66S	30OCT80	80.828	ND	ND	ND	ND	2
R67S	30OCT80	80.828	ND	ND	ND	ND	2
R68S	30OCT80	80.828	ND	ND	ND	ND	2
R70S	30OCT80	80.828	ND	ND	ND	ND	2
R94D	12MAR81	81.195	ND	ND	ND	ND	2
R94D	03MAR87	87.170	ND	ND	ND	ND	5
R94D	19MAY87	87.381	ND	ND	ND	ND	4
R94S	10MAR81	81.189	ND	ND	ND	ND	2
R94S	19MAY87	87.381	0.200	ND	ND	ND	4
R95S	07NOV86	86.852	ND	ND	ND	ND	5
R95S	03MAR87	87.170	ND	ND	ND	ND	5
R95S	19MAY87	87.381	0.200	ND	ND	ND	4

DATAGRP 1 Samples Collected and Analyzed by the Air Force 1979-1987
DATAGRP 2 Samples Collected and Analyzed by the USGS, 1979-1981
DATAGRP 3 Samples Collected and Analyzed by the USGS, 1982-1985
DATAGRP 4 Samples Collected and Analyzed by the USGS, 1987
DATAGRP 5 Samples Collected and Analyzed by the MDNR, 1987

(1) Water also contained 5.00 ug/L Bromodichloromethane and 1.30 Chloroform
(2) Water also contained 0.2 ug/L Toluene
(3) Water also contained 1.60 ug/L Bromodichloromethane
(4) Water also contained 0.2 ug/L Toluene
(5) Water also contained 0.2 ug/L Toluene
(6) Water also contained a trace amount of tetrachloroethane
(7) Water also contained 0.3 ug/L Toluene
(8) Water also contained 0.2 ug/L Toluene
(9) Water also contained 0.2 ug/L Toluene
(10) Water also contained 0.57 ug/L Dichloropropane 1,2-
(11) Water also contained 0.2 ug/L cis 1,2 DCE
(12) Water also contained 4.80 ug/L Bromodichloromethane, 0.51 Dichloropropane 1,2-, 0.54 Tetrachloroethane 1,1,2,2-
(13) Water also contained 0.2 ug/L Toluene
(14) Water also contained 0.5 ug/L cis 1,2 DCE
(15) Water also contained 1.2 ug/L Chloroform
(16) Water also contained 0.8 ug/L Chloroform
(17) Water also contained 0.4 ug/L Toluene
(18) Water also contained 0.5 ug/L Toluene
(19) Water also contained 1.3 ug/L Chloroform; 1.2 ug/L DCA
(20) Water also contained 0.3 ug/L Chloroform
(21) Water also contained Trace of Ethylbenzene and Toluene
(22) Water also contained 1.4 ug/L Chloroform; 6.8 ug/L DCA

(23) Water also contained 0.3 ug/L Chloroform
(24) Water also contained 0.1 ug/L Dichlorofluoromethane
(25) Water also contained 1.10 ug/L 1,1,1 TCA
(26) Water also contained 0.4 ug/L 1,1,1 TCA
(27) Water also contained 5.60 ug/L 1,1,1 TCA
(28) Water also contained 9.70 ug/L 1,1,1 TCA
(29) Water also contained 8.5 ug/L 1,1,1 TCA
(30) Water also contained 0.55 ug/L Bromodichloromethane

. Data missing, not collected, or not reported
ND Not Detected

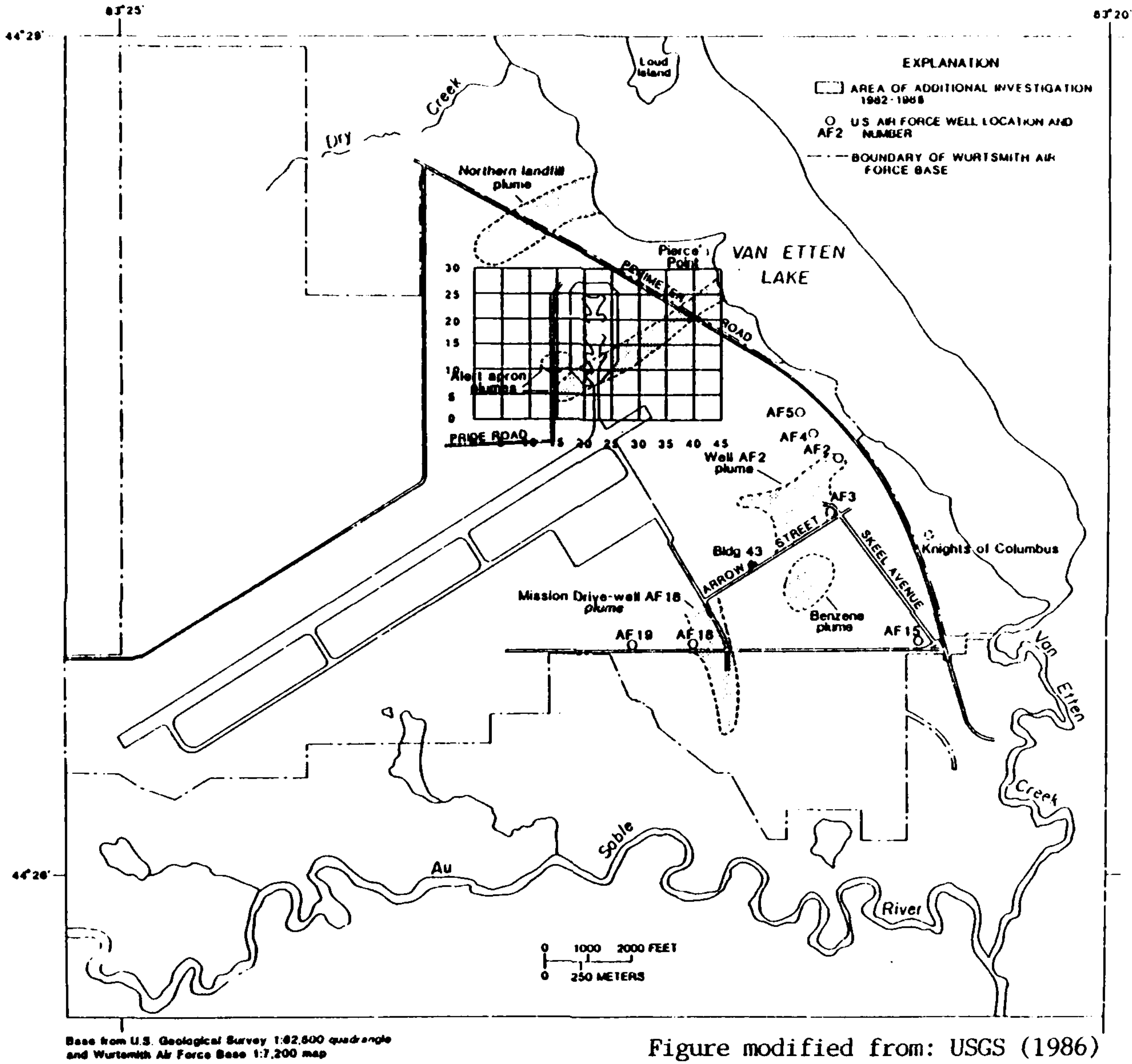

Figure modified from: USGS (1986)

Approximate Location of the Well Coordinate Grid for the Alert Apron Plume, Wurtsmith AFB MI

ALERT APRON PLUME

MONITORING WELL GRID COORDINATES

WELL	X COORDINATE	Y COORDINATE
AF22	30.6	19.3
PIERCE	39.2	25.0
R1S	29.3	23.8
R2D	40.8	11.7
R2S	40.8	11.7
R12D	27.8	27.5
R13D	34.5	20.1
R13S	34.5	20.1
R19D	34.4	22.7
R19S	34.4	22.7
R20D	40.6	17.9
R21S	36.7	6.1
R27D	32.5	23.5
R27S	32.5	23.5
R28S	37.7	26.5
R29S	37.7	25.0
R30S	36.5	23.2
R31S	36.4	21.6
R32S	31.2	22.0
R33S	32.3	21.2
R34S	33.3	20.4
R35S	26.7	17.2
R36D	27.3	16.0
R36S	27.3	16.0
R37S	28.0	15.3
R40S	24.4	15.0
R41S	28.6	14.3
R42S	24.7	11.4
R44S	22.6	12.1
R45S	20.4	8.7
R46S	17.6	9.5
R47S	18.5	8.1
R48S	19.3	6.7
R49S	14.3	10.5
R50D	14.5	7.8
R50S	14.5	7.8
R51S	14.5	6.7

R52S	14.8	5.4
R54S	16.6	14.7
R55S	16.7	13.0
R56S	14.2	14.4
R57S	14.3	12.5
R58S	17.0	11.0
R59S	14.4	9.3
R60S	18.0	8.7
R62S	8.7	9.2
R63S	12.6	6.9
R64S	12.3	6.0
R65S	12.5	4.8
R66S	0.2	8.8
R67S	0.4	6.6
R68S	0.6	4.4
R70S	7.4	0.0
R94S	25.9	24.7
R95S	26.1	23.4

APPENDIX B

Northern Landfill Data

This appendix contains a listing of all of the data collected from the monitoring wells in the Northern Landfill area. The variables which are listed in this data base include well identification number, date (two forms), TCE concentration, DCE concentration, benzene concentration, and data group. Vinyl chloride data which was used in the analyses is found in the footnotes at the end of the data listing.

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NORTHERN LANDFILL PLUME

WELL	DATE1	DATE2	TCE	DCE	BEN	DATAGRP
AF65	08OCT80	80.768	ND	18.000	9.900	2
AF65	10MAR81	81.189	ND	9.400	7.600	2
AF66	08OCT80	80.768	ND	ND	ND	2
AF66	10MAR81	81.189	ND	ND	ND	2
H33S	27APR83	83.321	ND	24.000	12.000	3
H33S	28JUN84	84.489	11.000	19.000	ND	3
H33S*	03JUN87	87.422	38.000	5.000	0.400	4
H34S	27APR83	83.321	ND	6.800	11.000	3
H34S	28JUN84	84.489	ND	29.000	ND	3
H34S(1)*	03JUN87	87.422	ND	6.200	5.300	4
H35S	27APR83	83.321	ND	6.700	4.800	3
H35S(2)	28JUN84	84.489	ND	71.000	ND	3
H35S(3)*	03JUN87	87.422	ND	8.300	7.000	4
H75S(4)	28JUN84	84.489	7.200	ND	ND	3
H75S(5)*	03JUN87	87.422	ND	0.500	0.300	4
H76D	28JUN84	84.489	ND	ND	ND	3
H76D	02JUN87	87.419	ND	ND	ND	4
H76S	28JUN84	84.489	ND	ND	ND	3
H76S	02JUN87	87.419	ND	ND	ND	4
H77D	28JUN84	84.489	ND	ND	ND	3
H77D(6)*	02JUN87	87.419	ND	6.300	0.900	4
H77S	28JUN84	84.489	ND	45.000	ND	3
H77S	01OCT84	84.749	ND	95.000	ND	3
H77S(7)*	03JUN87	87.422	ND	3.300	6.800	4
H78D	28JUN84	84.489	ND	252.000	7.200	3
H78D(8)*	03JUN87	87.422	ND	2.300	ND	4
H78D(9)	03JUN87	87.422	ND	2.300	6.600	5
H78D(10)b	03JUN87	87.422	ND	ND	5.100	5
H78D(29)	23NOV87	87.896	ND	ND	<2.100	1
H78S(11)	28JUN84	84.489	ND	36.000	218.000	3
H78S(12)*	03JUN87	87.422	0.900	ND	2100.000	4
H78S(13)	03JUN87	87.422	ND	ND	3000.000	5
H78S(14)b	03JUN87	87.422	ND	ND	2900.000	5
H78D(30)	23NOV87	87.896	0.400	ND	725.100	1
H79D	28JUN84	84.489	ND	6.000	ND	3
H79S	28JUN84	84.489	ND	20.000	ND	3
NK	01OCT84	84.749	ND	ND	ND	3
NK	16JUN87	87.457	ND	ND	ND	5
NK	05AUG87	87.594	ND	ND	ND	1
NR	19OCT82	82.800	ND	ND	ND	3
NR	05AUG87	87.594	ND	ND	ND	1
NS	19OCT82	82.800	ND	ND	ND	3
NS	01OCT84	84.749	ND	ND	ND	3
O4D	20DEC79	79.970	ND	ND	ND	2
O4D	10JAN80	80.027	ND	ND	ND	2
O4D	31JAN80	80.085	ND	ND	ND	2
O4D	05MAR81	81.175	ND	ND	ND	2
O4D	27JUN84	84.486	ND	ND	ND	3
O4D	02JUN87	87.419	ND	ND	ND	4

04S	14JAN79	79.038	13.100	.	.	1
04S	20DEC79	79.970	116.000	41.000	ND	2
04S	10JAN80	80.027	7.100	43.000	ND	2
04S	31JAN80	80.085	317.000	165.000	ND	2
04S	05MAR81	81.175	152.000	ND	ND	2
04S	23MAR81	81.225	120.000	ND	ND	1
04S	27APR81	81.321	130.000	ND	ND	1
04S	26MAY81	81.400	75.000	ND	ND	1
04S	22JUN81	81.474	51.000	ND	ND	1
04S	27JUL81	81.570	37.500	ND	ND	1
04S	24AUG81	81.647	13.000	ND	ND	1
04S	21SEP81	81.723	16.000	ND	ND	1
04S	26OCT81	81.819	5.200	ND	ND	1
04S	23NOV81	81.896	4.100	ND	ND	1
04S	21DEC81	81.973	5.200	ND	ND	1
04S	25JAN82	82.068	1.600	ND	ND	1
04S	22FEB82	82.145	2.500	ND	ND	1
04S	22MAR82	82.222	2.200	ND	ND	1
04S	05APR82	82.260	4.200	ND	ND	1
04S	03MAY82	82.337	8.300	ND	ND	1
04S	02JUN82	82.419	12.100	ND	ND	1
04S	28JUN82	82.490	7.100	ND	ND	1
04S	26JUL82	82.567	2.100	ND	ND	1
04S	23AUG82	82.644	2.300	ND	ND	1
04S	20SEP82	82.721	1.600	ND	ND	1
04S	04OCT82	82.759	2.500	ND	ND	1
04S	08NOV82	82.855	ND	ND	ND	1
04S	29NOV82	82.912	ND	ND	ND	1
04S	27DEC82	82.989	12.400	ND	ND	1
04S	24JAN83	83.066	10.000	.	.	1
04S	21FEB83	83.145	8.300	.	.	1
04S	28MAR83	83.238	3.500	.	.	1
04S	02MAY83	83.334	2.200	.	.	1
04S	31MAY83	83.414	1.900	.	.	1
04S	27JUN83	83.488	1.800	.	.	1
04S	24JUL83	83.562	0.900	.	.	1
04S	22AUG83	83.641	0.200	.	.	1
04S	19SEP83	83.718	0.200	.	.	1
04S	03OCT83	83.756	0.200	.	.	1
04S	31OCT83	83.833	0.400	.	.	1
04S	28NOV83	83.910	ND	.	.	1
04S	27DEC83	83.986	0.500	.	.	1
04S	31JAN84	84.085	19.600	ND	ND	1
04S	22FEB84	84.145	0.200	ND	ND	1
04S	19MAR84	84.213	ND	ND	ND	1
04S	02APR84	84.251	0.900	ND	ND	1
04S	07MAY84	84.347	2.300	ND	ND	1
04S	04JUN84	84.424	2.300	ND	ND	1
04S	25JUN84	84.481	3.500	ND	ND	1
04S	27JUN84	84.486	ND	ND	ND	3
04S	23JUL84	84.557	1.500	ND	ND	1
04S	20AUG84	84.634	2.800	ND	ND	1
04S	17SEP84	84.710	2.000	ND	ND	1
04S	01OCT84	84.749	2.700	ND	ND	1
04S	29OCT84	84.825	0.400	ND	ND	1

O4S	26NOV84	84.902	1.200	ND	ND	1
O4S	24DEC84	84.978	2.200	ND	ND	1
O4S	21JAN85	85.058	5.700	ND	ND	1
O4S	25FEB85	85.153	19.800	ND	ND	1
O4S	18MAR85	85.21	17.600	ND	ND	1
O4S	01APR85	85.249	31.000	ND	ND	1
O4S	29APR85	85.326	2.600	ND	ND	1
O4S	28MAY85	85.405	7.300	ND	ND	1
O4S	24JUN85	85.479	3.800	ND	ND	1
O4S	22JUL85	85.556	3.700	ND	ND	1
O4S	19AUG85	85.633	4.700	ND	ND	1
O4S	03SEP85	85.674	3.100	ND	ND	1
O4S	07OCT85	85.767	ND	ND	ND	1
O4S	04NOV85	85.844	ND	ND	ND	1
O4S	16DEC85	85.959	ND	ND	ND	1
O4S	03MAR86	86.170	6.900	ND	ND	1
O4S	31MAR86	86.247	4.900	ND	ND	1
O4S	05MAY86	86.342	6.200	ND	ND	1
O4S	12MAY86	86.362	0.800	ND	ND	1
O4S	27MAY86	86.403	7.700	ND	ND	1
O4S	09JUN86	86.438	2.400	ND	ND	1
O4S	30JUN86	86.496	5.900	ND	ND	1
O4S	05JAN87	87.014	8.000	ND	ND	1
O4S	02FEB87	87.104	0.800	ND	ND	1
O4S	02MAR87	87.167	3.600	2.700	ND	1
O4S	30MAR87	87.244	46.000	2.700	ND	1
O4S	05MAY87	87.342	15.100	8.300	ND	1
O4S	02JUN87	87.419	24.000	4.300	ND	4
R14D	20DEC79	79.970	ND	ND	ND	2
R14D	10JAN80	80.027	ND	ND	ND	2
R14D	03MAY80	80.336	ND	ND	ND	2
R14D	05MAR81	81.175	ND	ND	ND	2
R14D(15)	02JUN87	87.419	ND	ND	ND	4
R14S	03MAY80	80.336	ND	29.000	13.000	2
R14S(16)	05MAR81	81.175	ND	23.000	9.100	2
R14S(17)*	02JUN87	87.419	ND	2.000	9.000	4
R16D	20DEC79	79.970	ND	ND	ND	2
R16D	10JAN80	80.027	ND	ND	ND	2
R16D	03MAY80	80.336	ND	6.000	ND	2
R16D	05MAR81	81.175	ND	ND	9.800	2
R16S	14JAN79	79.038	ND	.	.	1
R16S	03MAY80	80.336	<1.000	37.000	5.900	2
R16S	23MAY80	80.391	<1.000	ND	ND	2
R16S	05MAR81	81.175	ND	39.000	4.800	2
R16S	01APR85	85.249	0.300	ND	ND	1
R16S	04JUN85	85.425	5.800	ND	ND	1
R16S	19AUG85	85.633	3.200	ND	ND	1
R16S	04NOV85	85.844	0.200	ND	ND	1
R16S	03JAN86	86.008	ND	ND	ND	1
R16S	05MAY86	86.342	ND	ND	ND	1
R16S	01JAN87	87.003	ND	ND	ND	1
R16S(18)	02JUN87	87.419	ND	ND	4.800	4
R22D	10MAR81	81.189	ND	ND	ND	2
R22D	02JUN87	87.419	ND	ND	ND	4
R22S	03MAY80	80.336	<1.000	29.000	28.000	2

R22S	23MAY80	80.391	ND	31.000	8.900	2
R22S	10MAR81	81.189	ND	17.000	3.100	2
R22S(19)*	02JUN87	87.419	ND	1.100	0.800	4
R39S	12JUN80	80.445	ND	ND	ND	2
R39S	14AUG80	80.617	ND	ND	ND	2
R39S	13MAR81	81.197	ND	ND	ND	2
R39S	19OCT82	82.800	ND	ND	ND	3
R39S	28JUN84	84.489	ND	ND	ND	3
R39S(20)	02JUN87	87.419	ND	ND	ND	4
R88D	02MAR81	81.167	ND	155.000	9.000	2
R88D	10MAY82	82.356	ND	147.000	ND	1
R88D	17MAY82	82.375	ND	0.500	ND	1
R88D	15NOV82	82.874	ND	ND	ND	1
R88D	14FEB83	83.123	ND	ND	ND	1
R88D	22FEB83	83.145	ND	7.300	ND	1
R88D(21)	27APR83	83.321	ND	222.000	7.200	3
R88D	16MAY83	83.373	ND	7.100	ND	1
R88D	22AUG83	83.641	ND	ND	ND	1
R88D	21NOV83	83.890	0.200	98.000	ND	1
R88D	05MAR84	84.175	0.500	142.000	ND	1
R88D	14MAY84	84.366	ND	151.000	ND	1
R88D	28JUN84	84.489	ND	52.000	ND	3
R88D	20AUG84	84.634	ND	4.600	ND	1
R88D	24DEC84	84.978	1.200	1.900	ND	1
R88D	18MAR85	85.211	18.000	3.000	ND	1
R88D	20MAY85	85.384	ND	189.000	ND	1
R88D	19AUG85	85.633	10.000	358.000	ND	1
R88D	23DEC85	85.978	0.900	205.400	ND	1
R88D	16FEB86	86.129	ND	ND	ND	1
R88D	27MAY86	86.403	TR	49.700	ND	1
R88D	25NOV86	86.900	ND	7.400	ND	1
R88D	16FEB87	87.129	ND	ND	ND	1
R88D(22)*	03JUN87	87.422	ND	4.700	2.300	4
R88S	02MAR81	81.167	ND	145.000	3.100	2
R88S	10MAY82	82.356	ND	258.000	ND	1
R88S	17MAY82	82.375	ND	294.000	ND	1
R88S	06JUL82	82.512	ND	297.000	ND	1
R88S	27SEP82	82.740	2.600	.	ND	1
R88S	15NOV82	82.874	ND	ND	ND	1
R88S	14FEB83	83.123	ND	ND	ND	1
R88S	22FEB83	83.145	ND	8.000	ND	1
R88S(23)	27APR83	83.321	ND	349.000	10.000	3
R88S	16MAY83	83.373	ND	5.700	ND	1
R88S	22AUG83	83.641	1.300	176.000	ND	1
R88S	14NOV83	83.871	0.600	221.000	ND	1
R88S	27FEB84	84.158	0.400	193.000	ND	1
R88S	14MAY84	84.366	ND	46.000	ND	1
R88S(24)	28JUN84	84.489	ND	34.000	8.300	3
R88S	20AUG84	84.634	ND	0.900	ND	1
R88S	13NOV84	84.866	ND	2.400	ND	1
R88S	18MAR85	85.211	ND	2.200	ND	1
R88S	20MAY85	85.384	ND	20.000	ND	1
R88S	19AUG85	85.633	4.600	27.000	ND	1
R88S	23DEC85	85.978	1.800	9.000	ND	1
R88S	16FEB86	86.129	ND	ND	ND	1

R88S	27MAY86	86.403	TR	5.500	ND	1
R88S	25NOV86	86.900	ND	8.200	ND	1
R88S	16FEB87	87.129	ND	ND	ND	1
R88S(25)*	03JUN87	87.422	ND	16.000	3.400	4
R89D	02MAR81	81.167	ND	5.700	ND	2
R89D(26)	02JUN87	87.419	ND	1.400	1.600	4
R89S	02MAR81	81.167	ND	ND	ND	2
R90S	10MAR81	81.189	ND	4.100	5.900	2
R90S	22FEB82	82.145	ND	7.600	ND	1
R90S	10MAY82	82.356	ND	ND	ND	1
R90S	17MAY82	82.375	ND	ND	ND	1
R90S	30AUG82	82.663	ND	12.800	ND	1
R90S	15NOV82	82.874	ND	1.900	ND	1
R90S	21FEB83	83.142	ND	6.800	ND	1
R90S	16MAY83	83.373	ND	7.900	ND	1
R90S	22AUG83	83.641	0.200	33.000	ND	1
R90S	14NOV83	83.871	0.500	1.700	ND	1
R90S	27FEB84	84.158	ND	0.500	ND	1
R90S	14MAY84	84.366	ND	0.000	ND	1
R90S	20AUG84	84.634	ND	0.600	ND	1
R90S	13NOV84	84.866	ND	2.200	ND	1
R90S	18MAR85	85.211	ND	8.300	ND	1
R90S	20MAY85	85.384	ND	5.100	ND	1
R90S	19AUG85	85.633	0.700	12.000	ND	1
R90S	23DEC85	85.978	ND	1.200	ND	1
R90S	16FEB86	86.129	ND	ND	ND	1
R90S	27MAY86	86.403	TR	9.300	ND	1
R90S	25NOV86	86.900	ND	7.800	ND	1
R90S	16FEB87	87.129	ND	ND	ND	1
R90S(27)*	02JUN87	87.419	ND	8.000	2.500	4
R91S	10MAR81	81.189	ND	ND	ND	2
R92S	10MAR81	81.189	ND	ND	ND	2
R92S(28)*	02JUN87	87.419	ND	4.900	5.400	4
R93S	10MAR81	81.189	ND	ND	ND	2
R93S	02JUN87	87.419	ND	ND	ND	4

DATAGRP 1 Samples Collected and Analyzed by the Air Force 1979-1987
DATAGRP 2 Samples Collected and Analyzed by the USGS, 1979-1981
DATAGRP 3 Samples Collected and Analyzed by the USGS, 1982-1985
DATAGRP 4 Samples Collected and Analyzed by the USGS, 1987
DATAGRP 5 Samples Collected and Analyzed by the MDNR, 1987

(1) Water also contained 2.5 ug/L of Vinyl Chloride
(2) Water also contained 15 ug/L of 1,1 DCA
(3) Water also contained 10.0 ug/L of Vinyl Chloride
(4) Water also contained 12 ug/L of bromoform
(5) Water also contained 0.2 ug/L of Vinyl Chloride
(6) Water also contained 6.2 ug/L of Vinyl Chloride
(7) Water also contained 8.6 ug/L of Vinyl Chloride
(8) Water also contained 19.0 ug/L of Vinyl Chloride
(9) Water also contained 29.0 ug/L of Vinyl Chloride,
1.20 Trans-1,2,-Dichloroethene
(10) Water also contained 34.0 ug/L of Vinyl Chloride,
1.40 Trans-1,2,-Dichloroethene

(11) Water also contained 54 ug/L of 1,1,1 TCA; 22 ug/L 1,1 DCA; 9.3 ug/L Toluene; 188 ug/L Ethylbenzene

(12) Water also contained 27.0 ug/L of Vinyl Chloride

(13) Water also contained 39.0 ug/L of Vinyl Chloride, 15.0 1,1-Dichloroethane, 9.10 1,1,1-Trichloroethane, 300 Ethylbenzene, 89.0 Xylene Isomers

(14) Water also contained 35.0 ug/L of Vinyl Chloride, 14.0 1,1-Dichloromethane, 9.30 1,1,1-Trichloroethane, 290 Ethylbenzene, 85.0 Xylene Isomers

(15) Water also contained 0.8 ug/L of Vinyl Chloride

(16) Water also contained 3.8 ug/L Toluene

(17) Water also contained 9.8 ug/L Vinyl Chloride

(18) Water also contained 62.0 ug/L Vinyl Chloride

(19) Water also contained 1.2 ug/L Vinyl Chloride

(20) Water also contained 0.2 ug/L Toluene

(21) Water also contained 11 ug/L 1,1 DCA; 5.4 ug/L 1,2 DCA

(22) Water also contained 13.0 ug/L of Vinyl Chloride

(23) Water also contained 105 ug/L 1,1 DCA

(24) Water also contained 23 ug/L 1,1 DCA

(25) Water also contained 20.0 ug/L of Vinyl Chloride

(26) Water also contained 9.1 ug/L of Vinyl Chloride

(27) Water also contained 0.6 ug/L of Vinyl Chloride

(28) Water also contained 2.6 ug/L of Vinyl Chloride

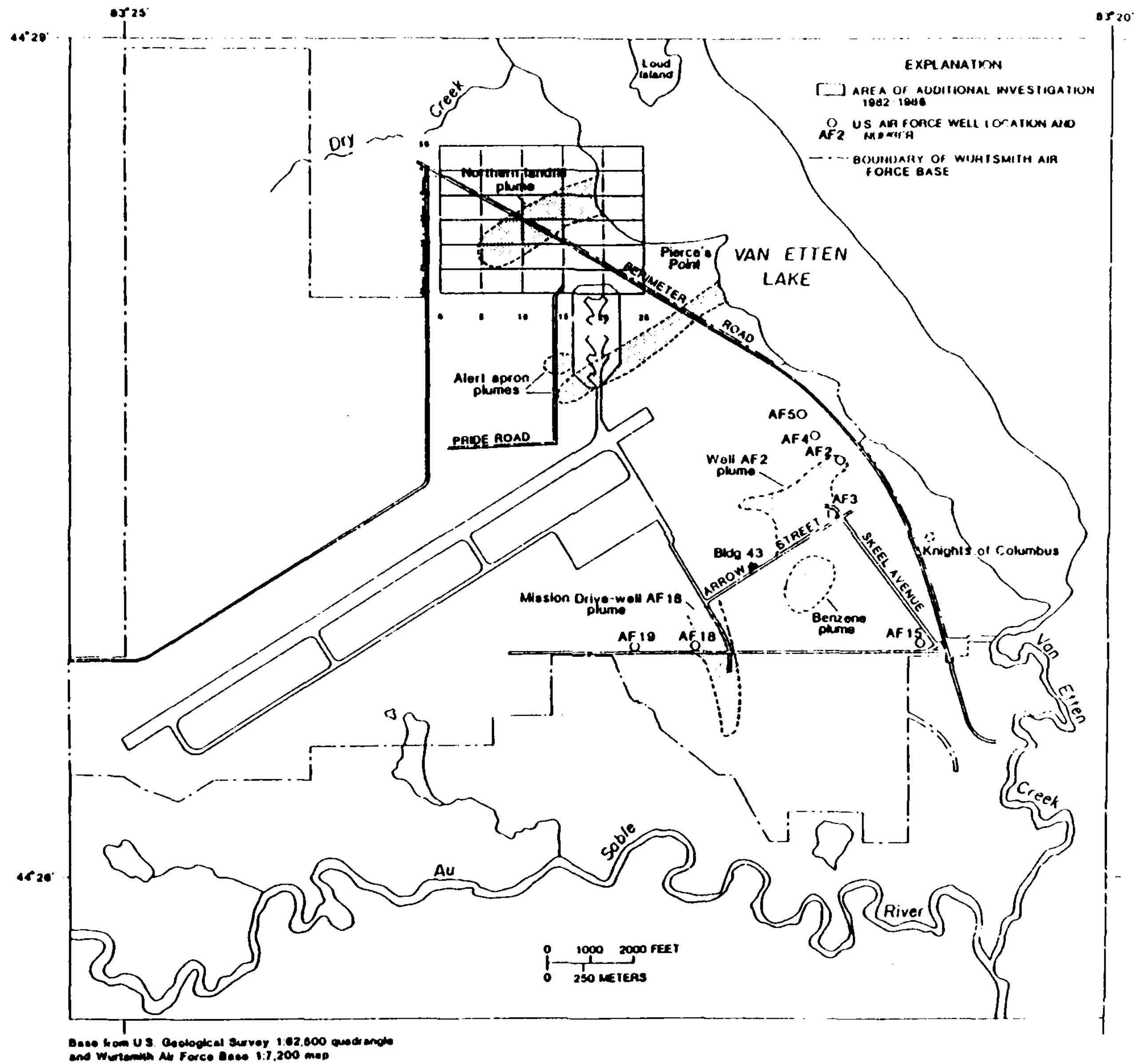
(29) Water also contained 2.2 ug/L of Chlorobenzene, 1.1 ug/L 1,1 DCA, 7.1 Trans 1,2-Dichloroethane, and 44.6 ug/L Vinyl Chloride

(30) Water also contained 63.0 ug/L of Chlorobenzene, 2.7 ug/L Toluene, 232.0 Ethylbenzene, 10.6 ug/L 1,1 DCA, 2.2 ug/L trans 1,2 - Dichloroethene, 0.6 ug/L 1,2 - Dichloropropane, 8.7 ug/L 1,1 - Trichloroethane, 15.2 ug/L Vinyl Chloride

. Data missing, not collected, or not reported

* cis 1,2 TCE

b Bailed



Approximate Location of the Well Coordinate Grid for the Northern Landfill Plume, Wurtsmith AFB MI

NORTHERN LANDFILL PLUME

MONITORING WELL GRID COORDINATES

WELL	X COORDINATE	Y COORDINATE
AF65	3.5	31.0
AF66	15.3	30.5
H33S	19.8	37.7
H34S	18.5	38.5
H35S	18.5	39.6
H75S	18.4	44.2
H76D	14.4	44.2
H76S	14.4	44.2
H77D	14.9	41.5
H77S	14.9	41.5
H78D	15.2	39.3
H78S	15.2	39.3
H79D	16.7	36.6
H79S	16.7	36.6
N K	14.4	50.0
N R	13.0	47.0
N S	16.4	45.3
O4D	12.6	32.1
O4S	12.6	32.1
R14D	8.6	34.6
R14S	8.6	34.6
R16D	4.7	31.8
R16S	4.7	31.8
R22D	5.1	27.9
R22S	5.1	27.9
R39S	17.3	34.7
R88D	13.0	35.2
R88S	13.0	35.2
R89D	12.2	36.4
R89S	12.2	36.4
R90S	8.9	37.3
R91S	4.4	38.5
R92S	1.5	32.7
R93S	6.8	25.4

APPENDIX C

Van Etten Lake Data

This appendix contains a listing of the data gathered from the analysis of water samples taken from Van Etten Lake. This data listing includes site identification, date (two forms), TCE concentration, PCE concentration, and data group.

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VAN ETTEN LAKE WATER SAMPLE DATA
All Data in ug/L

SITE	DATE	DATE	TCE	PCE	DATAGRP
3MSHLW	13JUL81	81.532	.	.	1
3M2/3	13JUL81	81.532	ND	ND	1
10MSHLW	13JUL81	81.532	.	.	1
10M2/3	13JUL81	81.532	ND	ND	1
30MSHLW	13JUL81	81.532	.	.	1
30M2/3	13JUL81	81.532	ND	ND	1
3MSHLW	18JAN82	82.049	ND	ND	1
3M2/3	18JAN82	82.049	ND	ND	1
10MSHLW	18JAN82	82.049	ND	ND	1
10M2/3	18JAN82	82.049	ND	ND	1
30MSHLW	18JAN82	82.049	ND	ND	1
30M2/3	18JAN82	82.049	ND	ND	1
3MSHLW	12JUL82	82.529	.	.	1
3M2/3	12JUL82	82.529	ND	ND	1
10MSHLW	12JUL82	82.529	.	.	1
10M2/3	12JUL82	82.529	ND	ND	1
30MSHLW	12JUL82	82.529	.	.	1
30M2/3	12JUL82	82.529	ND	ND	1
3MSHLW	14FEB83	83.123	.	.	1
3M2/3	14FEB83	83.123	ND	ND	1
10MSHLW	14FEB83	83.123	.	.	1
10M2/3	14FEB83	83.123	ND	ND	1
30MSHLW	14FEB83	83.123	.	.	1
30M2/3	14FEB83	83.123	ND	ND	1
3MSHLW	08AUG83	83.603	ND	ND	1
3M2/3	08AUG83	83.603	ND	ND	1
10MSHLW	08AUG83	83.603	ND	ND	1
10M2/3	08AUG83	83.603	ND	ND	1
30MSHLW	08AUG83	83.603	ND	ND	1
30M2/3	08AUG83	83.603	ND	ND	1
3MSHLW	06FEB84	84.101	244.000	.	1
3M2/3	06FEB84	84.101	271.000	.	1
10MSHLW	06FEB84	84.101	36.000	.	1
10M2/3	06FEB84	84.101	23.100	.	1
30MSHLW	06FEB84	84.101	103.000	.	1
30M2/3	06FEB84	84.101	30.200	.	1
3MSHLW	20FEB84	84.139	0.200	.	1
3M2/3	20FEB84	84.139	0.200	.	1
10MSHLW	20FEB84	84.139	ND	.	1
10M2/3	20FEB84	84.139	ND	.	1
30MSHLW	20FEB84	84.139	ND	.	1
30M2/3	20FEB84	84.139	ND	.	1
3MSHLW	27FEB84	84.159	13.500	.	1
3M2/3	27FEB84	84.159	17.500	.	1
10MSHLW	27FEB84	84.159	32.900	.	1
10M2/3	27FEB84	84.159	30.800	.	1
30MSHLW	27FEB84	84.159	.	.	1

30M2/3	27FEB84	84.159	.	.	1
3MSHLW	05MAR84	84.178	111.000	.	1
3M2/3	05MAR84	84.178	107.000	.	1
10MSHLW	05MAR84	84.178	17.100	.	1
10M2/3	05MAR84	84.178	18.100	.	1
30MSHLW	05MAR84	84.178	.	.	1
30M2/3	05MAR84	84.178	.	.	1
10SN	24APR84	84.314	ND	ND	2
33SN	24APR84	84.314	ND	ND	2
33DN	24APR84	84.314	ND	ND	2
100SN	24APR84	84.314	ND	ND	2
100DN	24APR84	84.314	ND	ND	2
10SH	24APR84	84.314	2.500	4.100	2
33SH	24APR84	84.314	ND	ND	2
33DH	24APR84	84.314	ND	ND	2
100SH	24APR84	84.314	ND	ND	2
100DH	24APR84	84.314	ND	ND	2
10SP	24APR84	84.314	ND	ND	2
33SP	24APR84	84.314	ND	ND	2
33DP	24APR84	84.314	ND	ND	2
100SP	24APR84	84.314	ND	ND	2
100DP	24APR84	84.314	ND	ND	2
3MSHLW	27JUL84	84.571	.	.	1
3M2/3	27JUL84	84.571	ND	ND	1
10MSHLW	27JUL84	84.571	.	.	1
10M2/3	27JUL84	84.571	ND	ND	1
30MSHLW	27JUL84	84.571	.	.	1
30M2/3	27JUL84	84.571	ND	ND	1
3MSHLW	26FEB85	85.157	0.400	ND	1
3M2/3	26FEB85	85.157	0.300	ND	1
10MSHLW	26FEB85	85.157	0.200	ND	1
10M2/3	26FEB85	85.157	0.200	ND	1
30MSHLW	26FEB85	85.157	TR	ND	1
30M2/3	26FEB85	85.157	0.200	ND	1
3MSHLW	19AUG85	85.633	TR	ND	1
3M2/3	19AUG85	85.633	ND	ND	1
10MSHLW	19AUG85	85.633	ND	ND	1
10M2/3	19AUG85	85.633	0.700	ND	1
30MSHLW	19AUG85	85.633	ND	ND	1
30M2/3	19AUG85	85.633	ND	ND	1
3MSHLW	23SEP85	85.729	1.000	ND	1
3M2/3	23SEP85	85.729	ND	ND	1
10MSHLW	23SEP85	85.729	ND	ND	1
10M2/3	23SEP85	85.729	ND	ND	1
30MSHLW	23SEP85	85.729	ND	ND	1
30M2/3	23SEP85	85.729	ND	ND	1
3MSHLW	09FEB86	86.110	2.000	ND	1
3M2/3	09FEB86	86.110	ND	ND	1
10MSHLW	09FEB86	86.110	ND	ND	1
10M2/3	09FEB86	86.110	0.800	ND	1
30MSHLW	09FEB86	86.110	ND	ND	1
30M2/3	09FEB86	86.110	0.400	ND	1
3MSHLW	01SEP86	86.668	2.200	ND	1
3M2/3	01SEP86	86.668	ND	ND	1
10MSHLW	01SEP86	86.668	ND	ND	1

10M2/3	01SEP86	86.668	0.800	ND	1
30MSHLW	01SEP86	86.668	ND	ND	1
30M2/3	01SEP86	86.668	0.400	ND	1
3MSHLW	09FEB87	87.110	ND	ND	1
3M2/3	09FEB87	87.110	0.800	ND	1
10MSHLW	09FEB87	87.110	17.200	ND	1
10M2/3	09FEB87	87.110	17.100	ND	1
30MSHLW	09FEB87	87.110	.	ND	1
30M2/3	09FEB87	87.110	.	ND	1

DATA GROUP 1 Data collected and analyzed by Air Force
DATA GROUP 2 Data collected and analyzed by USGS

D or S USGS samples taken deep or shallow
N,H, or P USGS samples indicates line of sampling
ND Not Detected
TR Trace
3M 3 Meters Off-shore
SHLW Samples taken at shallow depth
2/3 Sample taken at 2/3 depth
. Data not collected or missing

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